MINISTRY OF AGRICULTURE AND FISHERIES,
DEPARTMENT OF AGRICULTURE FOR SCOTLAND, AND
MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

REPORTS

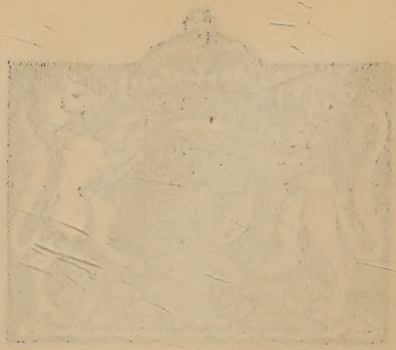
on the work of

Agricultural Research Institutes

and on certain other agricultural
investigations in the

United Kingdom.

1928-1929.



The present volume takes the place of a Paper of the Agricultural Research Council containing summaries of work in progress at Agricultural Research Institutes which has been prepared annually for the information of the Council, and which has also been circulated in typescript among other persons interested. The demand for copies has now become so great as to necessitate printing.

The volume for the academic year 1928-1929 has been expanded by the inclusion of reports on agricultural research in Northern Ireland, and on investigations by research-workers in England, Wales and Scotland, who are not attached to Research Institutes. Lists of papers published during the year have, however, been omitted: they have been replaced by the annual volume of "Abstracts of Papers on Agricultural Research in the United Kingdom"(1).

For the convenience of those desiring further information regarding the subjects dealt with in the reports, an appendix has been added containing the names and addresses of Directors of Research Institutes and other persons in charge of institutions at which investigations are in progress: enquiries should be addressed accordingly.

Ministry of Agriculture and Fisheries,
10, Whitehall Place,
London, S.W.1.

August, 1930.

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(1) Volumes for 1926-27, 1927-28 and 1928-29 are obtainable from the Ministry at the above address. Price 1/- net each volume. Post free.

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I.

RESEARCH INSTITUTE INVESTIGATIONS.

A.

SOILS, PLANT NUTRITION and PLANT PHYSIOLOGY.

1. ROTHAMSTED EXPERIMENTAL STATION.

The investigations at Rothamsted are concerned with the growth of crops in health and disease and they have developed in three directions :—

(1) The influence of fertilisers on the growth, composition and quality of the crop.
(2) The cultivation and management of the soil.
(3) The diseases and pests of plants, their causes and means of control.

Field Technique.—The effect of fertilisers on the growth of crops is being studied by the new methods of field experimentation which have the great advantages of allowing of the calculation of the standard error and so giving figures that can be related to weather and other data. The standard error per plot is about 8 per cent. for cereals, rather less for potatoes and more for sugar beet : but some experiments come out much better, values of 3 or 4 per cent. per plot being not uncommon. It is evident that field technique can be further improved and efforts are being made to do this.

Composition and Quality of Crops.—The investigations on composition and quality of the crop are made in conjunction with expert users. The most extensive are on barley. Dr. Bishop shows that the amount of nitrogen in the barley plant is related to the supply in the soil, and that the proportion of the different nitrogen compounds in the plant depends only on the total nitrogen and not on soil or season. With increase in nitrogen there is an increase in the proportion of hordein and a decrease in the proportion of simpler compounds, but the proportion of glutelin remains unaltered. This ratio of glutelin to total nitrogen appears to be a fundamental varietal constant of great importance to the maltster. For a given variety the amounts of the individual proteins are accurately measured by the total nitrogen. Further, Dr. Bishop shows that the total nitrogen of the barley together with a thousand corn weight can be used to give fairly accurate estimates of the amounts of extract and of different groups of nitrogen compounds in the resulting malt.

From a study of the great mass of data at Rothamsted relating to the growth of barley it has been possible to work out certain relationships between conditions of growth and the nitrogen supply of the plant.

An extensive series of experiments has been made on the effect of fertilisers on the keeping and cooking qualities of potatoes. This work is being done in conjunction with Messrs. Lyons, who are making a number of chemical determinations such as starch, in their own laboratories. The data are not yet complete.

Experiments on wheat are made in conjunction with the Milling Research Institute.

Experiments on Grass.—The method of feeding animals on the pasture is being discarded owing to its liability to serious error, and

instead, frequent cuttings are made, the technique somewhat resembling that adopted at Aberystwyth and Cambridge.

The influence of fertilisers on the habit and character of growth of the ordinary farm crops is being studied in detail with the purpose of recording diagnostic symptoms that would help the expert in recognising deficiency in any particular nutrient supply.

Weather and Yield.—Much attention has been paid to the influence of weather conditions on the yield of crops grown under different fertiliser treatment. The different fertilisers vary in their effectiveness according to the weather conditions. The nitrogenous fertilisers appear to be least influenced by seasonal factors, but they tend to act most effectively in the seasons of lowest yield. Potassic fertilisers seem to be most useful in sunless seasons or years of spring droughts ; phosphatic fertilisers act well under generally unfavourable conditions.

In the Statistical Department investigations under Drs. Fisher and Wishart have been continued into the Rothamsted and Woburn field data ; fuller and more precise relationships with weather and soil conditions are sought.

Properties of Fertilisers.—Much work has been done jointly by the Chemical, Botanical, and Plant Physiological Departments on the properties of fertilisers. Statistics show that since the war farmers have increased their consumption of nitrogenous and potassic fertilisers more than their consumption of phosphatic ; presumably in consequence of the decrease in area under swedes. The experiments show, however, that neither nitrogen nor potash is completely effective unless adequate amounts of phosphate are also applied, and from the data now accumulating it is hoped to work out suitable proportions of the three nutrients in different conditions.

A new basic slag has been brought under experiment. It is of low solubility but contains only little fluorine and thus differs considerably from the older low soluble slags.

Much experimental work has been done with cyanamide, which has certain special properties including the power of increasing tillering of barley on an acid soil. It should be applied some seven days before drilling the seed, but where this is impracticable it is better applied just before drilling than some days afterwards, as has been recommended. Also it is more likely to do harm when worked into the soil than when laid on the surface. When mixed with superphosphate it changed into dicyanodiamide, a harmful substance : this mixture should therefore not be made.

Superphosphate added to the soil remained in the surface layers so long as the soil remained neutral. But on an acid soil (one of the grass plots made acid by long continued treatment with sulphate of ammonia) some phosphate was lost from the surface soil though it has not in the course of 70 years travelled more than 3 ft. down into the soil. The availability of the phosphorus compounds in the soil appeared to be increased by the addition of soluble sodium silicate ; this has no consistent effect on the amount of phosphate in the soil

solution but it depresses the solubility of calcium and may thus indirectly facilitate the uptake of phosphate by the plant.

Inoculation of Lucerne.—The Bacteriology Department has been concerned mainly with the study of the nodule organism of the lucerne plant. The inoculation process has been so far developed that it can now be used on a large scale, and the details have been handed over to Messrs. Allen and Hanbury who will henceforward supply the cultures to farmers.

The relationship of the organism to the plant has, however, been further studied. It is shown that the organisms cannot enter the plant until the true leaves begin to form : there is then extruded from the root a substance which stimulates them to multiply round the root and to enter it. The nature of this substance is not yet determined, but it does not appear to be made in the leaf. When the organisms are in the root they increase greatly in number, and they stimulate the plant cells to multiply, forming the well-known nodules. Around the colony of bacteria a network of conducting vessels develops as an offshoot from the main circulating system of the plant, and, this close connection being established, the bacteria take sugar from the plant juice and fix nitrogen, converting it into soluble compounds which pass back into the plant, causing an increase in growth. If the supply of sugar is cut off by keeping the plants in the dark, or by stopping the development of the conducting vessels (which can be done by withholding the trace of boron needed for this purpose), the bacteria turn to the root tissue for food and begin to consume it : they thus change from being beneficial into harmful parasites. If the supply of air is restricted the bacteria fix less nitrogen but they do not become parasitic.

Decomposition of Cellulose.—Much work has been done to discover the organisms effecting the decomposition of cellulose in the soil. A considerable number can do it : the determining factor at any time appears to be the reaction of the soil. The organisms that multiply most when cellulose is added to the soil and therefore are presumably the chief agents decomposing it, are, in acid soil (pH 4 to 5) the fungi and actinomycetes ; in less acid conditions (pH 5·5 to 6·5) *Spirochaeta cytophaga* ; and in neutral soils (pH above 6·5) the short rod-like cellulose-decomposing bacteria. This investigation harmonises a number of apparently inconsistent results obtained by previous workers. Some humus is formed from fungus mycelium, but only from certain fungi, not from all.

Purification of Sugar Beet Effluents.—The work on the purification of sugar beet effluents carried out at the Colwick factory has been further developed and a purification of 90 per cent. has now been attained. Much detailed work is still needed, however, to ensure the regular maintenance of this standard.

Soil Cultivation.—The investigations on soil cultivation fall into two divisions : field tests using the dynamometer and other means of

measurement, and laboratory experiments to explain and amplify the field results. Rotary cultivation has been further tested : it is of considerable promise, as giving a tilth with less labour than by the ordinary method. The laboratory examination of the field measurements is difficult but soil properties related to them are gradually being discovered : of these the static rigidity, or energy needed to cause a soil paste just to flow, is closely related to dynamometer measurements : the viscosity of the paste, or more strictly the pseudo-viscosity, shows, on the other hand, a more complex relationship which is being further examined.

The physical chemistry of clay is being developed, especially the increase in acidity when a neutral salt solution is added to clay. The drop in pH value is lower than can be explained by the replacement of hydrogen ions by the cations of the salt : the disturbing factor appears to be the potential difference through which the hydrogen ions must escape from the surface of the clay particle.

Growth of Grasses in Pasture.—The experiments begun two years ago on the factors concerned in the growth of grasses in pasture are now indicating certain competition effects which are being further developed. Species of large growth habit lower the tillering and growth rate of species of smaller growth habit ; thus Italian Rye grass behaved as an " aggressor " to Perennial Rye grass, Cocksfoot, Timothy and Rough-stalked Meadow grass. Although it prevented these others from making their full growth it did not by itself make its full growth : indeed larger weights per plant were obtained when it was grown in competition with Perennial Rye grass and especially with Rough-stalked Meadow grass.

Mycological Investigations.—In the Mycological Department, the fundamental physiological and genetical work on fungi is continuing. Strains of *Botrytis cinerea* which appear identical in structure and cultural reactions differ markedly in pathogenic properties, and conversely strains different in structure and cultural reactions have similar pathogenic properties : for example one strain is parasitic on Nicandra, oats and sweet pea, and harmless to sugar beet, tobacco and broad beans, while another, indistinguishable in appearance and culture relations, is harmless to Nicandra and oats but parasitic on sweet pea and sugar beet : it is harmless also to tobacco and broad beans. Much work is needed to clear up the difficulties of this complex subject.

In studying wart disease of potatoes certain new hosts were discovered : *Solanum dulcamara* var. *Villosissimum*, and var. *alba* : *S. nudiflorum* : *S. Villosum* : *Nicandra physalodes* : in some of the host plants the fungus occurred in the tissues but showed little or no signs of its presence.

The Black Arm or Angular Leaf Spot disease of cotton has been closely studied. The causal organism, *B. malvacearum*, is capable of wide variations in shape and size according to its conditions of growth ; it has also methods of reproduction quite different from the

usual simple vegetative division. It can even change into entirely new cultural types : one is identical with the common yellow saprophyte of cotton : this is only slightly virulent but under certain conditions it appears to be capable of reverting to the normal or even a more virulent type.

The relation of the organism to the plant is being studied.

Virus Disease.—The work on virus disease has been considerably extended by a team of workers. A localised form of the disease has been found in *Datura stramonium* and *Lycium chinense* where certain parts of the plant only are affected, the rest being free not only from symptoms but also from virus, so that the juices can be inoculated into highly susceptible plants without result. This is most unusual : in other instances the disease affects the whole plant.

The remarkable bodies present in the cells in infected plants have also been studied.

Entomological Investigations.—The Entomological work is largely concerned with the parasites of insect pests, these being among the most important agencies for effecting control in nature. As an example : meadow foxtail is liable to attack by gall-midges. In 1928 the attack in a particular instance was slight : there was 38 per cent. parasitism. In 1929 in the same experiment the attack was heavy : there was only 3 per cent. of parasitism. A new parasite of the frit fly has been found : a Chalcid *Callitula bicolor.* Another important observation is the greatly increased prevalence of *Loxotropa tritoma* and decline of the Chalcid *Halticoptera fuscicornis,* two phenomena which are apparently correlated.

Another method of control now being tested is to alter the cultivation of the crop so as to make it less suitable to the insect. Thus by delaying the flowering of Meadow Foxtail grass till after the main flight period of the midges was over—as can be done by early cutting or grazing—the attack was reduced from 80 per cent. to just over 10 per cent. Control of the frit fly is obtained by earlier sowing of the oats.

The breeding of stocks of insects for weed control in New Zealand having passed beyond the research stage has now been handed over to the Farnham Royal Laboratory of the Imperial Bureau of Entomology, which is specially equipped for this purpose.

Dr. Davidson having been appointed to the Waite Research Institute, South Australia, the investigations on aphides with which he was associated have been discontinued.

The insecticide investigations have been mainly concerned with pyrethrum, one of the most promising of vegetable products, as it can apparently be grown satisfactorily in this country.

Bees.—The investigations on bees have followed the lines of previous years and the accumulated data are being worked up. It is possible now to set out the relative advantages and disadvantages of the "warm way" and "cold way" of arranging the frames. Feeding tests have so far shown no differences in effect between cane

sugar and beet sugar as winter food nor anything to justify the preference for the cane sugar. The "brood food" swarming hypothesis is being tested, and valuable information obtained, by the study of marked bees, about the ages at which they are engaged upon specific activities.

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2. NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

Research in Soils and Drainage.

Soil Investigation.—The death of Mr. Newlands, the Advisory Officer in Soils, early in the year under review greatly curtailed the activities of this department. In view of the developments which are taking place and which are likely to lead to the foundation of a Research Institute for Soils, no successor to Mr. Newlands has been appointed. Shortly before his death Mr. Newlands prepared two papers for publication on the relation between the growth of sugar beet and properties, especially the acidity, of the soil. These papers were published after his death, one in the "Scottish Journal of Agriculture" and the other in the "Journal of Agricultural Science." The most important fact which they bring out is that the failure of the sugar beet crop in this district is commonly due to the soil being too acid. Mr. Newlands left much unfinished work, and that on the composition and properties of local soils and on the soil survey of the district, on which he was engaged, has had to stand still for the present.

Any enquiries and requests for advice on soil and fertility problems have been dealt with since Mr. Newlands, death by Professor Hendrick, with the help of other members of the Staff.

Drainage.—The work of collecting data from the lysimeters has been continued on the usual lines. During 1929 the crop on the lysimeters was hay, which showed in a very marked manner the effect of a heavy grain crop in smothering out the clover from the seeds. No. 3 lysimeter is both manured and limed, and usually gives by far the heaviest crop, and this was the case with the barley crop, but the hay on this lysimeter was almost a failure and contained very little red clover. On the other hand, the hay crop on the unmanured lysimeter was a good one and contained much clover. The analyses of the drainage water will show whether there has been much loss of manurial material from No. 3 under these conditions.

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3. CHEMICAL (AND ANIMAL NUTRITION) DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Soils and Fertilizers.—An investigation into the liming problem in Northern Ireland, designed to obtain information as to the benefits of liming from the point of view of feeding value of crops as well as that of yield, has been put into operation. Experimental plots have been laid down at four centres and it is hoped to extend the number next year.

A potato manurial experiment in which plots were treated with the standard fertilizer dressing supplemented with varying proportions of nitrogenous and potassic fertilizers has been carried out. Although the results are only of a preliminary nature there was no indication of increased crop yields when the proportion of nitrogen and potash was increased.

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4. RESEARCH INSTITUTE OF PLANT PHYSIOLOGY, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

Effect of Manures on Barley.—An experiment was carried out to investigate the effect of concentration of nutrient solution on the rate of uptake of ions and on the growth of barley. The plants were grown in carefully washed sand, and by the use of specially designed siphons were automatically irrigated continuously with the culture solutions at the rate of 10 litres per day. The solutions contained nitrogen and potash in excess, and in addition ten different concentrations of phosphate. A mixture of sodium monohydrogen and potassium dihydrogen phosphates was used in such proportions as to give a neutral reaction, and such quantities as to contain 0, $\frac{1}{4}$, $\frac{1}{2}$, 1 . . . . . .64 parts per million of P_2O_5. The solutions were made up in tap water, which on analysis was found to contain less than 0.1 parts per million P_2O_5. Two samples each of 3 pots and a final sample of 6 pots were removed from each series during the experiment, the plants divided into separate parts, dry weighted, and prepared for chemical analysis. Counts of tiller number were done weekly. Tiller number and dry weight increased slowly with increasing concentration up to 2 parts per million ; from 2-8 parts the increase was very rapid, while above 8 parts per million the rate of increase declined. A sample taken in July after ear emergence showed a maximum dry weight at 16 parts per million, and in the higher concentrations the plants subsequently died, before ripening of the grain. The dry-weight concentration curve is found to have a point of inflexion near about 4 parts per million, the yield increasing more than proportionally to the external concentration below this point, and with " diminishing returns " above this concentration.

Electro-culture Investigation.—A pot-culture experiment comprising 768 pots has been carried out to test the relation of the electric discharge to different types of manuring, four different concentrations of nitrogen, four different concentrations of phosphate, and two different concentrations of potash being employed. The types of electrical treatment were four in number. A number of significant differences were obtained but there was a certain amount of attack by rust which increased the variance of the material. When the results of the different manurial sets are combined it is found that, as in previous years, electrical treatment for the middle period of growth is the most effective, since such treatment gave results which, when compared with the controls, were just not significantly higher but gave differences of marked significance when compared with treatment for either an early or a late period. The effect of a late discharge seems in part to undo the favourable effect of a discharge applied during an earlier period. In relation to the reproduction coefficient (the ratio of grain yield to total dry weight of aerial parts) the results of previous years are confirmed. As in previous years it has also been found that the plants subjected to the discharge for an intermediate period show the lowest proportion of sterile flowers in the ears.

Effect of Nitrogen, Phosphates and Potash on Grasses.—A series of investigations has been planned dealing with the general and specific effects of nutrient deficiency and competition on various species of pasture grasses. The experiment in progress during the growing season 1929 aimed at an exact study of the effect of deficiency of the elements nitrogen, phosphorus, and potassium on the following grasses :—Italian Rye, Cocksfoot and Rough-Stalked Meadow grass. The grasses were grown in pure culture, on sand in glazed pots. Fortnightly samples were taken and three replicate pots of each treatment analysed into leaf, stem, root and dead matter ; fresh and dry weights of these were determined, tiller numbers counted, and an estimate of the leaf area obtained. From these analyses a variety of information has been obtained of the behaviour of the three species under such conditions. So far as the analysis of the results has proceeded at present, it may be said that very highly significant differential responses of the species to the types of nutrient applied have been obtained in the dry weight data of at least total tops, roots, stems and leaves. It has been shown also that different parts of the same grass respond differentially to varying nutrient treatment ; thus the ratios of root-weight to top-weight and of leaf to stem, are very significantly different with different treatments in any one species ; and this differential response itself varies differentially among the three species. An interesting differential response of the three species to treatment in respect of the number of tillers produced has been revealed. Italian Rye produces many more tillers under phosphorus deficiency than under nitrogen deficiency, while in Cocksfoot the effect is just as marked but is reversed ;

Rough-Stalked Meadow grass shows no real difference between the two treatments as regards tiller number. A considerable amount of information in the data collected has yet to be critically examined.

Vegetative Propagation of Fruit Trees.—Trials have been continued of the influence of external conditions upon the rooting of cuttings of varieties difficult to propagate. Attention is still being concentrated on soil and atmospheric moisture and although preliminary experiments with shelters have not given good results, closer regulation of soil moisture is promising. (This work is carried out at the East Malling Research Station.)

Stem Diameter of Fruit Trees and New Shoot Growth.—A report on this subject is ready for publication. It has been shown how the differences in stem diameter of plants subjected to different methods of pruning are determined, the amount of increase in diameter depending on the proximity to growing shoots and also, it appears, upon the type of shoot-growth made. (This work is carried out at the East Malling Research Station).

Seasonal Course of Root and Shoot Development in Apple Stocks.—Although considerable knowledge has accumulated as to the total amount of stem growth made during the year by fruit trees, little is known as yet about the variations in this rate of growth at different seasons of the year, or of the effect of local climatic conditions upon this rate; with regard to root growth still less is known. It is not known for certain at what season the roots grow fastest, at what time they become dormant, how long they remain dormant, or indeed, if they become completely dormant at all. A knowledge of the seasons of maximum and minimum growth and of their relation to local climatic conditions will obviously be of value in connection with all fruit studies. To fill this gap in our knowledge, preliminary investigations have been begun this year on one year old trees of Stock No. XIII. Samples of trees have been harvested at intervals of about a month from spring onwards, and the increments in weight of the various organs determined, by taking the dry weights of the leaves, shoots and roots. This work will be continued, and will be extended to older trees. (This work is carried out at the East Malling Research Station).

Work with Enhanced Concentrations of Carbon Dioxide.—An attempt has been made to determine whether the enrichment of the air with carbon dioxide, which is known to accelerate the growth of plants, could be carried on in some less expensive way than by use of the liquid gas or its release from carbonates by means of acid. Experiments were therefore undertaken in which the carbon dioxide was supplied from the combustion of oil. Preliminary experiments were carried out with cucumber plants in small glass frames through which the products of combustion were led, so as to bring the concentration of carbon dioxide up to a level of 12 parts in 10,000 of air. In spite of the crudity of the experiment an

increase in dry weight of 18·5 per cent. in 17 days was obtained. In the summer of 1929 experiments with tomato plants were carried out—by the kind permission of Dr. Bewley—in one of the experimental houses of the Cheshunt Experimental Station. The treated plants were exposed to air supercharged with carbon dioxide by the gases of combustion derived from four oil burners. The concentration reached varied from 10 to 20 parts per 10,000 of air according to the degree of ventilation employed. The burners were normally in action for about 7 hours a day and the treatment was continued during May, June, July and August. The yield from the experimental chamber was 346 lbs. as against 294 lbs. from the control chamber, an increase of 17·7 per cent.

B.

PLANT BREEDING, CROP VARIETIES and SEEDS.

5. PLANT BREEDING INSTITUTE, CAMBRIDGE UNIVERSITY.

Wheat (R. H. Biffen and F. L. Engledow).—The policy governing work still in the earlier stages is as follows: In winter wheat types peculiarly adapted to heavy land are being sought. There are many such forms now at the F_4 stage. The suitability of Rivet wheat for such land and its restored market value (now that poultry food is so important) have led to extensive selection of commercial stocks. A large number of types has been isolated and tested for the first time this season. In spring wheats earliness, better straw and yield are the chief requirements. The main series of hybrids is now at the F_4 or F_5 stage.

The possibility of producing a series of wheats with the 28 chromosomes of the emmer and Rivet groups instead of the 42 of the ordinary bread wheats is being investigated. Work on the inheritance of disease-resistance is being continued. No progress was made with it in 1929 owing to the almost complete absence of the diseases under investigation.

A four years' study of the quality of wheat for biscuit making was interrupted by a mill-fire. It is hoped to continue it during 1930.

The following, after careful small scale plot trials, will in the coming year be under large scale test by the N.I.A.B.—

Winter Wheats—three hybrids from the cross Yeoman by White Fife; the objective is to secure yet higher grain quality.

Spring Wheats—one hybrid of the April Bearded type but of better standing capacity and higher yield; another of the same ripening period as Red Marvel but superior in standing power and in grain.

Wheat (A. E. Watkins).—The investigation into sterility and inheritance in species crosses was continued. Its results throw light on a number of problems encountered in previous wheat-breeding experiments. It has now involved a critical study of all available wheats and a collection for this purpose has been got together from the greater part of the Mediterranean region, Iraq, Persia and China. Much of this material is being distributed to other workers in different parts of the Empire with, amongst other objects, that of obtaining information on resistance to stem-rust.

Oats (H. Hunter).—As previous reports have indicated, the investigations with oats have largely taken the line of attempts to produce improved winter sorts and in the season 1928-29 the majority of the new hybrid forms studied were in the F_6 stage. The character of the winter 1928-29 was such as to assist materially in determining which of the new forms reached a sufficiently high standard of winter hardiness to justify their retention for further propagation. The results obtained during the past season confirm the impression previously formed in less extreme conditions that winter hardiness

is exhibited in varying degrees in the various hybrid progenies. Thus in the new forms obtained by crossing Grey Winter and different spring oats there are degrees of hardiness extending from that of the Grey Winter on the one hand to that of the spring parent on the other.

Despite the unusual dry conditions which succeeded a hard and extended winter the oats under observation made good growth and the straw was long enough to afford some idea of its strength under such conditions of storm as that of July 28th. The quality of the grain of 1929 harvest remains to be determined, but there are sufficient indications that the outstandingly good forms of previous years have maintained the quality they exhibited before. Some of the most winter hardy forms possess a better standing straw than the Grey Winter parent and a quality of grain not inferior thereto. These are being increased in bulk in 1929-30 and should be ready for propagation on a field scale in 1930-31.

The cross between Bountiful and Grey Winter produced several promising cultures which will be increased in bulk in 1930 concurrently with those of Grey Winter × Argentine.

At one time it looked as if the drought would so seriously limit the growth of the spring sown oats as to render them valueless for comparative purposes. Fortunately this was not the case and the crops of new varieties which have been bred for rapid early development and earliness in ripening were thus obtained under the most exacting conditions they are likely to encounter. This has provided a very severe test of grain quality and one that enables the number of selections to be materially reduced.

As in the case of the spring oats bred for earliness, this season has provided a final eliminating test for a series of new forms procured by crossing Black Potato and Victory. The character of straw in these forms was determined in earlier years but the quality of grain was a matter of doubt until this season.

Barley (F. L. Engledow).—Sufficient stocks of the following barleys have been obtained for large scale trials in the coming year :—

Spring Barleys—two hybrids which received their final (3rd year) test for yield and malting value by the N.I.A.B. in 1928-9.

Winter Barleys—a hybrid which is winter hardy and, though of 6-row type, has proved of high quality in actual malting tests ; its standing capacity is high.

It is too early as yet to pronounce on the possibilities of a winter 6-row malting barley and no fresh work will be started until the hybrid mentioned above has been more widely grown. Spring barley policy remains unaltered and the most recent series of hybrids is derived from a small number of the best of the existing types which are in commerce and notably Spratt-Archer and Plumage-Archer.

Swedes (M. S. Pease).—For some time past the genetics of non-bulbing swedes has been under investigation. Specimens of abnormal bulb-less plants have frequently been sent to the Institute and, where an examination of the crop has been practicable, they have been found to occur at random and side by side with perfectly normal swedes. The " rogue " has the typical foliage and flowers of the swedes, but in place of the bulb it has woody and often branched stems. All of the plants tested so far have proved to be fully self-fertile and their progeny is of the " rogue " type.

The Institute is anxious to collect further particulars about the occurrence of these " rogues " and to be given facilities for inspecting crops in which they are to be found.

Sugar Beet (A. E. Watkins).—The investigations were continued and trials made of various methods for storing mother-beets during the dormant period.

Beans (H. Hunter).—Of the three similar beans previously selected for winter hardiness and productivity No. 7 survived the winter well both in the selection tests and as a field crop on the University Farm. The produce of the latter crop has been widely distributed amongst local farmers. Its propagation from a single plant will be repeated.

The various selections of spring beans chosen for rapidity of early development and earliness in ripening maintained differences in these directions despite the very dry summer conditions and the most promising are now ready to be raised into bulks. As there was no Aphis this year their resistance to or escape by rapid growth from this pest could not be observed.

Peas (F. L. Engledow).—It is proposed to finish selection of existing commercial varieties in peas before new hybridisations are commenced. A survey of varieties and synonyms has been made and after one more year's trial selections of the following will be ready for large scale trial by the N.I.A.B., viz., Dun, Maple, Black Eyed Susan. Meantime two hybrid series—the one at F_4 and the other at F_6—are being dealt with. Both aim at what is believed to be the ideal field pea—an early, short haulm, maple-seeded type, with small, round, well filled seed.

Four selections from foreign seed which are likely to compete with the standard variety Prussian Blue are being tested.

Yield.—In the immediate past the effect of various factors on the yield of farm crops has been under investigation. During 1928-29 enquiries were started on the influence of drainage and the application of nitrogenous manures, using the same technique as in previous years.

Investigation into Good and Bad Fields of Wheat.—Some seven years ago it became necessary to ascertain the essential features of " field conditions " as opposed to plot conditions. This led to a study of the density of plant populations in field crops, the influence

of density upon development at all stages of growth, and upon final yield. Very great fluctuations in density from point to point were found and a separate investigation traced the responsibility for these to the seed drill and showed in what precise respects typical drills were defective.

A further result of the general enquiry was to show that the number of ears formed per plant depended essentially upon the period in growth at which tillering occurred. An immediate issue which arose from this observation was the question of the exact biological influence of nitrogenous top dressings and of the relation of time of application of such dressings to yield. It was shown that top dressings as applied in ordinary farm practice increased yield per acre solely by increasing ear size. It may be inferred therefore that by giving a very early application, together with a normal spring application, greater increase in yield might be expected. Experiments to test this are now in their second year. They are being carried out by the stations in Norfolk, Hertfordshire and Cambridge in co-operation.

As a side issue to the general investigations, corresponding studies were made on sugar beet. It was shown that a very substantial increase in yield might be brought about on all typical sugar beet fields by securing a fuller and more even crop. The means whereby this might be done were closely explored.

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6. WELSH PLANT BREEDING STATION, ABERYSTWYTH.

The season under review has provided the best weather conditions for the work in progress since the foundation of the Station. Although an exceptionally dry summer, rain fell sufficiently often and in sufficient quantity.

Cereals.—The work of selection with pure lines of Hen Gymro Wheat (Mr. T. J. Jenkin) was completed during the session and five lines have been distributed to centres in Wales where this old variety is still largely grown. The severe winter provided a rigid test of the segregates of White Winter Oats bred by Mr. E. T. Jones : some of the segregates withstood the conditions very well and showed excellent standing properties. Segregates from crosses made with varieties like Record and Victory with a variety of *Avena sterilis* are showing promise of high-yielding capacity with decidedly good standing ability.

Herbage Plants : Breeding.

Cocksfoot (The Director).—The work has now advanced a long way towards the fixing of (*a*) an extra-leafy hay type and (*b*) three distinct pasture types.

Meadow Foxtail (The Director).—The remarkable results given by a comparatively pure breeding leafy strain in the matter of early keep under the influence of nitrogenous manures has made it desirable further to develop researches with this species upon which it had been intended to discontinue work.

Other Grasses (Mr. T. J. Jenkin).—The work with the rye-grasses, timothy, red fescue, *Phalaris* and other species continues to make good progress along established lines. An interesting result has been the very heavy bulks of herbage given by a pedigree red fescue early in the spring, and although in general the fine-leaved fescues are not particularly palatable to sheep at this early period of the year, the produce from the pedigree strains is much relished. The researches with a view to fixing three interesting types of timothy, namely, an extra-leafy hay type (which for long-duration leys may well replace the ordinary commercial timothy), an intermediate hay-pasture type, which has given excellent results in field plot trials, and an extreme pasture type, are proceeding very favourably. The extreme pasture type was found to be similar to that met with on very old English grasslands, and it is evident that it will be possible to build up a pedigree strain remarkably true to this type which is likely to prove to be a very valuable pasture grass. Two relatively pure-breeding lines of smooth stalked meadow grass, which are very different in behaviour from the ordinary commercial, are being proceeded with and will perhaps prove valuable for the drier and poorer soils.

In regard to the genetical work on grasses, Mr. Jenkin is accumulating a mass of data on the inheritance of dwarfism and of base colour in perennial rye-grass—subjects upon which he will be in a position to publish a paper comparatively soon. The work on wider crosses with grasses continues to be exceedingly interesting. By a system of back crossing fertile hybrids have now been obtained from original crosses made with perennial rye-grass and meadow fescue, while the same is true of crosses originally made between *Phalaris arundinacea* and *P. nodosa* : some of these latter hybrids are exceptionally bulky and rather promising grasses, although as yet no pure-breeding lines have been obtained.

Clovers and other Legumes. (Captain R. D. Williams).—In the case of red clover, strains more persistent than the ordinary Cornish marl or Montgomery have been obtained by intercrossing selected extra-persistent plants and by the crosses made between the late-flowering red clovers and selected wild reds. Both wild red clover and wild white clover are now being studied from the ecotypical point of view and large collections of both species have been obtained from various parts of the world, and are now under detailed study.

The work with the genus *Lotus* is being steadily pushed forward and a very large number of forms have been found to exist in both species.

General Grassland Researches.

Technique for employing sheep and trials with sheep. (Mr. L. I. Jones).—The preliminary trials with tethered sheep have been greatly extended, and it can now be said with some confidence that tethering will prove a very valuable addition to the methods of dealing with grassland problems.

During the period under review 16 pairs of tethered lambs and sheep have been successfully used for experimental purposes. With the help of tethered sheep it has been found possible to institute an important enquiry relative to the effect of the biotic factor on grassland. Various intensities of grazing are being tested on a considerable range of pasture types by this means, while it has been found possible to use tethered sheep instead of penned sheep for a considerable number of the tests which are now being conducted on a field scale with the Station's pedigree strains of grasses.

Seeds Mixtures. (Mr. M. T. Thomas, acting for Mr. Wm. Davies loaned to New Zealand).—A considerable number of the plots laid down with a view to critical study of competitive influences in seeds mixtures are now in their fourth harvest year, and botanical analyses are being continued on these, while investigations as to the proper time to sow annual clovers have been extended to yellow suckling clover, and a paper on the results obtained is now in preparation.

Higher Manuring of Grassland. (Mr. W. E. J. Milton, Mr. M. T. Thomas, in conjunction with Mr. T. W. Fagan, Advisory Chemist). —These trials have been considerably extended, and tethered sheep are proving very useful.

Seed Production. (Mr. Gwilym Evans).—Preliminary manurial trials have been conducted relative to seed production. These seem to show that, to obtain maximum seed crops, the different species require very different manurial treatments, and that, in the case of cocksfoot particularly, it is more important to apply pretty heavy dressings of nitrogenous manures to the indigenous than to the non-indigenous strains.

Pathology.—Miss Kathleen Sampson is continuing her detailed investigations on *Epichloe typhina*, while a general survey continues to be made relative to the various fungus diseases that attack herbage plants.

7. SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING.

Oats.—Several series of hybrids, in the pedigree of which the early-ripening, black-grained oat Orion figures as one of the parents, were advanced another generation, and further comparisons and selections were made. A number of these selections are now in the 6th generation. Some of them are apparently breeding true, and they have now been marked for multiplication and preliminary field-trial. In selecting promising strains reference has been given to the white-grained types.

Further data have been obtained concerning the inheritance of grain colour in several crosses beteeen white and black-grained varieties. Certain crosses have been repeated in order to secure confirmation of previous results.

Twenty-two hybrid selections were compared in replicated field plots and a separate plot of each selection was grown for stock seed. The varieties grown as controls were Victory, Potato and Sandy. Several of the selections have given a higher yield of grain than Victory both in 1928 and 1929. One of these new varieties possesses short, stiff straw and also gives a high yield of grain under suitable conditions. As a result of the trials during the last three years at the Plant Breeding Station and at other centres this variety is being further multiplied with a view to its being put on the market. Favourable reports on the field trials of another new variety have been received from the North of Scotland and this variety is also being multiplied. These two varieties which have been multiplied in quantity, have been included in the Registration Trials carried out by the Department of Agriculture for Scotland, in 1928 and 1929. In these trials in 1928 the stiff-strawed variety referred to above gave the highest yield of grain.

Herbage Plants.—Since the critical examination of the grass species has revealed the presence of distinct growth forms within species, attention has been directed towards the study of competition between the growth forms within a species as distinct from interspecific competition.

Further progress has been made with the genetical analysis of species-populations collected in the wild, and data regarding variations and modifications are being accumulated with a view to securing information that will eventually assist in the isolation of types suited to the different agricultural conditions.

Species crossing has been limited to *Phlegm pratense* x *P. alpinum.* This work has given results of scientific interest, but it has not yet reached the stage where an indication of its economic value can be obtained.

The study of *Plantago maritima* has been continued. In addition to the results indicating a possible agricultural value for this species the investigations have yielded information which it is hoped to apply to the grass-breeding problems.

Potatoes.—The work on potatoes has been continued as in the previous three years. The main part of the investigations continued to be carried out at the Society's Sub-Station near Kirknewton, Midlothian, and included studies of (*a*) the heredity of several characters, (*b*) the effect of repeated selfing, (*c*) the relative merits of various pairs of varieties as parents for producing new immune varieties. Important data have been collected. Experiments were also carried out to determine the relative agronomic values of the more promising seedlings that were raised. As a result of repeated self-fertilisation further progress has been made towards establishing strains that will breed true to type.

A small stock of healthy plants of seedlings and named varieties is being maintained for crossing, and for the production of seed tubers for comparative trials at the Plant Breeding Station, Corstorphine and at other centres.

Families of crossed seedlings from Great Scot × Bell, Kerr's Pink × Bell, Kerr's Pink × Flourball, British Queen × Flourball, and from other crosses were grown for selection and comparision. The majority of the most promising of the older seedlings are maincrop or late varieties and greater attention is now being directed to the problem of obtaining earlier ripening types.

Of the older seedlings five were included in the Registration Trials of the Department of Agriculture for Scotland in 1929. During the growing period these varieties were noted for their freedom from virus disease and their vigorous growth.

As in previous years, seedlings were submitted to the Department of Agriculture for Scotland for inclusion in the trials for immunity from wart disease.

Field trials of the selected seedlings were made at the Plant Breeding Station, Corstorphine, and the results indicate that 15 selections were outstanding in respect of their cropping powers and their habit of growth, and that they compared very favourably with their controls (Kerr's Pink and Great Scot).

Swedes and Turnips.—Problems having a bearing on methods of breeding are being investigated, especially with regard to the practicability of producing true-breeding strains of swedes by continued self-fertilisation and artificial isolation.

Experiments were continued to discover the mode of inheritance of various morphological characters, of resistance to finger-and-toe disease and of constitutional " bolting "—i.e. " running to seed." The researches to trace the origin of the " bulbless bolter," a valueless type somewhat resembling rape, were further developed.

The trial of methods for selecting seed mothers on the basis of dry-matter content, together with weight and certain other considerations was continued. Two small yield trials were carried through to test certain pedigree strains ; on one of these dry-matter and sugar-content determinations were made.

8. PLANT BREEDING DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

An unusually severe winter aided very considerably selection work amongst supposedly winter-hardy strains of oats of hybrid origin. Surviving lines may be deemed sufficiently hardy for Northern Ireland and many such are perfectly satisfactory in other respects.

Selection amongst high tillering spring types, also of hybrid origin, was carried a stage further. Preliminary yield tests over a period of three years are now complete for a large batch of new strains, the best of which will now undergo field trials in all counties. Two of these strains, regarded as outstanding in advance of preliminary test results, were included in this season's field trials. The whole series of field trial results was subjected to close inspection with a view to identifying districts which appeared to favour consistently certain varieties. A preliminary map embodying the results of this survey has been constructed.

In flax the results of four years trials of the leading pure strains are now available but have not yet been published. These results indicate that two new strains are of outstanding merit and these are now being propagated to bulk.

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9. NATIONAL INSTITUTE OF AGRICULTURAL BOTANY.

Crop Improvement Branch.

(*a*) *Yield and quality trials and observation plots.*—Fresh varieties, selected from the previous season's observation plots, were introduced in the case of the winter wheat, spring oat, mangold and swede trials in 1928-29, but the principal innovation was the formal decision to test suitable varieties of cereals under conditions of intensive as well as of normal manuring. The Institute does not attempt to investigate manurial questions, it simply follows the best practice of the day in the manuring and cultivation of the trials ; but there are grounds for believing that some varieties respond better to intensive manuring than others, and it will be of value to agriculturists to know which varieties they should choose if they wish to farm highly, as well as which varieties are best adapted to normal conditions. The Institute has been fortunate in having the advice of Sir John Russell in the selection of manures, and the Research Farm of Imperial Chemical Industries Ltd. at Jealott's Hill has generously carried out the same set of trials under the Institute's direction but entirely at its own charges.

The varieties included in trials in the past season were :—

Wheat.—Squarehead's Master, Setter, Chevalier, Ideal, Victor, Wilhelmina, Iron III, Rivett, Yeoman, and a new stock from the Cambridge Plant Breeding Institute.

Winter Oats.—Bountiful, Marvellous, Plentiful and Victory.

Winter Barley.—Garton's six-row, Plumage-Archer 1924, and a new variety from the Cambridge Plant Breeding Institute.

Spring Oats.—Abundance (three stocks), Golden Rain II, Star, Thousand Dollar (under conditions of both normal and intensive manuring).

Spring Barley.—Spratt-Archer and two Cambridge Plant Breeding Institute barleys, Nos. 824 and 825 (under conditions of both normal and intensive manuring), two stocks of Archer and an Irish stock of Spratt-Archer.

Mangolds.—(*a*) Carter's Yellow Globe, Lord Warden and Golden Standwell, Garton's Large Orange Globe, Sutton's Sensation, E. Counties' Ipswich Globe and Cannell's New Century ; and (*b*) Webb's Red Intermediate, Johnson's Gatepost Yellow Intermediate, Cannell's Golden Gatepost, Garton's New Sugar and Kirsche's Ideal.

Swedes.—Sutton's Best of All, Cannell's Purple King, and Garton's Acme and Superlative.

Sugar Beet.—The same varieties as in 1928.

Lucerne.—Strains of Provence (Control) English, Grimms, Kansas, Hungarian, South African, Hunter River (New South Wales), and Marlborough (New Zealand).

Most of these trials were repeated at all the sub-stations and this is true of the extensive range of plots grown partly to demonstrate to farmers the characteristics of leading varieties and partly to provide preliminary information about the newer ones. In these plots there were in 1928-29 42 varieties of winter wheat, 5 winter oats, 10 winter barleys, 10 spring wheats, 24 spring oats, 21 spring barleys, and 39 strains of sugar beet, with a few plots of miscellaneous crops.

Mr. J. B. Gill, Secretary of the Essex Farmers' Union, has continued to collect records of their cereal crops from Essex farmers. The report on the 1927 crops issued during the year provided very useful information and broke new ground in the sphere of English agricultural records. A report on the 1928 crops is now in the press. The first opportunity will be taken of extending this work to other counties.

Active steps have for some time been taken to secure the co-operation of County Agricultural Organizers, and it is a pleasure to acknowledge the readiness with which it has been given and the interest which has been shown in the question of varieties. The practical result is that during the past season plots of different varieties of cereals were grown by Organizers in conjunction with the Institute at forty-six centres spread over fifteen counties. These

developments ensure that every farmer who wishes can without effort obtain reliable advice in the selection of the most remunerative varieties.

(*b*) *Equipment.*—A new granary has been built at Cambridge during the year, and equipped with threshing, drying and cleaning plant. The building is of a simple character and economical in design and operation, but it fills a long-felt want and will be invaluable for handling seed grain for experimental work and the comparatively small quantities which it is proposed to market annually; outside assistance will still be necessary to deal with new varieties in large bulks, but even in such cases the possession of the granary will materially lighten the Institute's task.

The investigation undertaken by the Norfolk Agricultural Station with the special sixteen coulter expanding cup drill manufactured for the Institute in 1927 has established its suitability for use in the trials. Five similar drills have accordingly been purchased and will be brought into use at the sub-stations in the autumn of 1929.

(*c*) *Seed Growing.*—For the 1930 season the Institute is offering at a fixed price to established dealers in seed corn small stocks of Abundance oats which have been kept comparatively free from *Helminthosporium Avenæ*, and Thousand Dollar oats. The latter not only yield rather better than Abundance but have a stronger straw and are consequently better adapted for land in good condition. Though purchasers will be free to re-sell at once at the recognised price, the purpose in offering these small quantities is to provide merchants with a nucleus stock of high quality from which to build up a larger bulk for sale in the ordinary way to farmers in subsequent seasons. Other varieties which the Institute is arranging to offer for similar purposes later on are Little Joss, Squarehead's Master and Wilhelmina wheats, and Grey Winter oats.

The original seed of these stocks of standard varieties was selected by the Cambridge University Plant Breeding Institute. From the same source has come the thirty new varieties of cereals which were included in the past season's trials or plots. Among them were the two new hybrid barleys, Nos. 824 and 825. They have now been tested for four years. Both are of distinct merit in yield and quality, and, in addition, withstand lodging exceptionally well. Nevertheless, judged on the basis of monetary return per acre, they show no superiority over Plumage-Archer and Spratt-Archer. It is the Institute's unvarying policy to market no new variety unless there is a clear proof that it would be of more value to the farmer than the best existing varieties. Accordingly the Institute has decided not to place on the market the new barleys Nos. 824 and 825.

The majority of the others are still in the early stages of testing; all of them show promise in one or more respects, but it is probably inevitable that most of them should be rejected before reaching the market. This negative function of rejecting all varieties but the best, though an unpleasant duty, is none the less one of the principal

services which the Institute can render to agriculture. The introduction of a new variety speaks for itself, but the very fact that there is nothing to show for the years of silent work which precede the final rejection of a variety makes it all the more necessary to reiterate that by such means alone can the farmer be saved the cost of experimenting with unknown varieties and the losses attendant upon growing unsuitable ones.

Official Seed Testing Station.

The Station tested in twelve months ended 31st July, 1929, routine samples to the number of 25,834 as well as 3,240 which were the subject of special investigations. The total of 29,074 is substantially more than in any previous season except 1927-28, when the total was 29,993. This small reduction of 3 per cent. was no doubt due to the fact that the good harvest conditions of 1928 made it unnecessary to send as many cereal samples for test as after the 1927 harvest. It was offset by an increase in the number of clovers and grasses, and as these are more difficult seeds to test, the amount of work falling on the staff was fully as much as in the previous season. None the less it proved possible to reduce the maximum number of analysts employed at any one time from twenty-five in 1927-28 to twenty-three in 1928-29.

The number of special investigations in progress is always considerable. The stage has now been reached at which it is convenient to review briefly some of the work undertaken with clovers and grasses. In the case of wild white clover, seed from hundreds of stocks from all parts of the country has been examined in the laboratory and then grown in the field for observation. As a result the Station is now in possession of a very considerable amount of information about the genuine stocks in this country. The plots have also been of assistance to merchants by enabling them to see for themselves the genuineness, or otherwise, of their growers' stocks. Next year the English Wild White Clover Certification Scheme will come into operation under the auspices of the Ministry of Agriculture and the National Farmers' Union. The Station has been entrusted with the responsibility of examining and growing for identification seed from inspected fields, and type samples of each certified crop will be deposited with it for these purposes. Furthermore, any purchaser of seed bearing a certificate number under this Scheme will be able, on request, to have it grown for identification by the Station at a nominal fee.

Red clover is also being studied with success. The Station grows a considerable number of samples each year from commercial bulks described as " Late-flowering Red Clover " with a view to obtaining information as to the accuracy of the description. Extensive laboratory studies are also constantly in progress for the purpose of checking the nationality of commercial stocks described as of English origin. As the result of this work it has been possible to supply

valuable evidence in recent years with respect to seed incorrectly sold as English.

Seeds of grasses adapted to the formation of turf already command high prices, and as the number of golf courses increases so does the demand for this class of seed. The Station has therefore paid particular attention for some years to such grasses, more especially the members of the two genera *Agrostis* and *Festuca*. Much confusion exists in commerce with respect to the seeds of these genera, particularly in the case of the genus *Agrostis*. By means of laboratory studies of the seeds, checked by greenhouse and field determinations, a considerable amount of information has now been amassed about both genera. While this work is primarily concerned with the accurate identification of the seeds commercially handled, yet a good deal of the information obtained is likely to be of value to all who are interested in the production of turf.

A seed testing course and examination and a conference of seed analysts have for some time been regular features of the Station's work. They were again carried out on the usual lines in the summer of 1929.

Potato Testing Work.

(*a*) *Yield and Maturity Trials of Potatoes.*—The trials undertaken in 1929 were of a more varied character than in any previous season, and it is satisfactory to record that in spite of the drought their growth and appearance left nothing to be desired. The recently introduced varieties Arran Banner and Incomer were tested against Great Scot, Majestic and Kerr's Pink at Ormskirk and against the same varieties and British Queen at Kirton. Trials at Ormskirk of Lancashire "once-grown" stock of Arran Crest, Macbeth's Castle, Ninetyfold and Epicure against Scottish stocks of the two latter suggested that in the case of first-earlies there are some advantages in using "once-grown" seed. Another trial was designed to test whether the suggestions drawn from some work in Cheshire—that it is unremunerative to use fertilizers with first-earlies—held good at Ormskirk ; Epicure was chosen for the purpose, but, whether the contradiction of the Cheshire results was due to soil or season or some other cause, the orthodox practice of using fertilizers as well as farmyard manure justified itself on this occasion. "Early-bulking" trials of first-earlies were carried out at both Ormskirk and Kirton, Arran Crest, Epicure, Herald, and Sharpe's Express being included at both centres, May Queen and Ninetyfold at Ormskirk only, and Eclipse at Kirton only. There was also a trial at Ormskirk, designed for the sole purpose of checking the Institute's technique, to see whether interference occurred when tall and low-growing varieties were planted side by side. Epicure and Harbinger were used, and the results were negative.

It was necessary in 1929 to have three separate trials for the Gold Medals offered by the Earl of Derby for new varieties immune

from wart disease which show outstanding promise when grown at Ormskirk. Mr. Pollock's seedling D.1 was entered as a first-early, but it proved to be too late in bulking, and even when it was ready for lifting the yield of saleable produce was relatively low. Accordingly no award was made. Sir Josslyn Gore-Booth's Alannah and a stock from Mr. Medland were entered as early maincrop varieties and were tested against Great Scot, Majestic, and Kerr's Pink; but they proved to be of insufficient merit to warrant an award. One other entry was received—a late maincrop, No. 675, from Mr. D. MacKelvie. This was tested against Golden Wonder, and in view of its cropping capacity, cooking quality and good tuber shape it was given a certificate of merit.

(*b*) *The Official Immunity Trials at Ormskirk.*—For the first time in the history of the Immunity Trials the whole of the distinct varieties were free from wart disease in the field. This was not due to any seasonal lack of wart disease, for, dry though the summer was, the control plots of susceptible varieties planted at short intervals among the new stocks developed wart disease freely. The gratifying conclusions can be drawn that the influence of the trials and of the work of geneticists on the breeding of immune varieties is becoming steadily more effective, and that the quick and efficient indoor method now used at Ormskirk for the susceptibility tests enables breeders to sort out their immune and susceptible seedlings at an earlier stage.

The Immunity trials consisted of 160 plots, 19 more than in 1928. Of these 62 were stocks entered for the first time, 17 were stocks entered for the second time, 30 were stocks sent from the official wart disease trial stations of Scotland and Northern Ireland in accordance with the system of exchange for ensuring that each authority is acquainted with all new immune varieties, 12 were miscellaneous stocks, 17 were key plots, and 22 were controls. Every one of the 64 distinct varieties included in the first and second year entries was for this season at any rate free from wart disease in the field. The whole of the entries were also tested indoors and no stock which remained free from wart disease indoors developed it in the field. The Susceptibility Trials, for which there were 153 entries, were carried out in the past season by the indoor method only, and senders thus received their reports towards the end of 1928 or early in 1929 instead of having to wait as hitherto until the autumn. More than 3,000 tubers were tested by the indoor method during the winter.

(*c*) *Potato Synonyms.*—The examination of, and report by the Synonym Committee upon the varieties entered for the Ormskirk trials, the growing of demonstration plots at Ormskirk of synonyms side by side with their type varieties, and the issue during the winter of a list of synonyms on offer in potato catalogues constitute the principal steps taken by the Institute during the past season to continue their policy of stamping out synonyms and establishing

the principle that one variety should have one name and one only, and conversely that no one name should be used for more than one variety. The Synonym Committee record that the percentage of synonyms entered for the trials has now fallen to 12 per cent. lower than ever before ; some even of these few were unquestionably entered in good faith. An examination of potato catalogues and other evidence coming from all parts of the country show that the situation is continuing to improve and that the activities of the Committee are widely appreciated by farmers and those who advise them. Its success has in fact led to a rapidly-growing demand that the Institute should undertake similar work with other farm crops.

(*d*) *Virus Disease.*—The investigation into the possibility of maintaining healthy stocks of seed potatoes in England by different methods of rogueing in the field has now reached an interesting stage. A stock of Majestic was divided into three parts in the spring of 1927, and these have since been grown at Ormskirk, one of three different treatments being given to each part. The effects of these treatments on yield and quality will be tested next year by carrying out a trial of the three stocks grown in 1929 against each other and the best obtainable Scottish stock. The Superintendent has also been engaged in an attempt to select healthy seed from diseased stocks of three varieties ; this work may extend over several seasons ; and he has begun a fresh set of trials to determine the relative resistance of six varieties to leaf-roll, from which it is hoped to obtain results next year.

There is perhaps nothing which holds out greater promise of increasing the yield of potatoes than the eradication of virus diseases. A corresponding degree of importance attaches to the success already attained by the Potato Virus Research Station at Cambridge in raising small virus-free stocks of established varieties. Plots grown from this seed at Ormskirk in 1929 produced plants of such vigour that an expert accustomed to the ordinary stocks of commerce might have been excused for failing to recognise them for the varieties which in fact they are. The Institute has been invited to co-operate with the Virus Research Station in the development of these stocks for the market, and if the difficult task of keeping them healthy during multiplication can be carried to a successful conclusion, substantial benefits must accrue to potato growers.

10. REGISTRATION STATION OF THE DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

Potatoes.

Laboratory Test for Immunity from Wart Disease.—The number of seedling potato varieties tested in the course of the year was 2427. Of these 633 proved to be susceptible to the disease under this test.

Registration Scheme.—This year 83 varieties were submitted for Registration test.

The number of varieties undergoing test for a second year was seven and for a third year, four.

One variety, Arran Crest, was recommended for registration as a new first early variety and duly registered by the Department.

Virus Diseases Scheme.—The four new varieties under test for registration in their third year were tested by the method of tuber grafting in terms of their reaction to infection by the four mosaic diseases—crinkle, interveinal mosaic, streak and mild mosaic.

All unit selections of apparently healthy plants or clones were tested by core grafting to healthy Arran Victory.

As a result of these tests and of independent field observations 45 per cent. of units selected in 1926-27-28 were discarded. There remain 149 units representative of nine varieties in process of being propagated as nuclei of healthy stocks. During 1929 the Station's officers extended this work and made unit selections of apparently healthy plants in 68 stocks of 12 varieties on 44 farms.

Oats.

Registration Scheme.—Twenty-three new varieties of oats were under observation in nursery plots as a preliminary to their being introduced into the Registration test proper.

Six varieties were submitted for registration and were subjected to a comparative test of yield and maturity in duplicate plots each 1/22 acre.

Five varieties were subjected to a final test in duplicate half-acre plots before being considered for registration.

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11. CROP [AND ANIMAL HUSBANDRY] RESEARCH DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Drainage.—Land drainage has always been a problem of importance in Northern Ireland, and in particular the removal of the surface water effectively. Tile or stone drains which involve heavy expenditure on manual labour for cutting the drains is so costly as to be, in many cases, almost prohibitive. The alternative form of draining, namely mole draining, has been shown by investigation to be rarely suitable under our soil conditions. Experiments have been carried out by the Division to explore the possibilities of reducing the cost of tile or stone draining by the employment of machinery to cut the drains. With this object in view a Simplex Soil Excavator was purchased and the Division has carried out a considerable number

of trials and observations with the machine. The Excavator cuts a trench of two feet in depth in two cuts. Under our conditions the first cut of 12 inches was performed with ease and through clay or peat portions the second cut was made with equal ease and a clean cut trench left ready for tiling. On most lands, however, the second cut was not successful owing to the presence of large stones, bog oak, etc., but even in these circumstances, good work was done in loosening the soil, etc., and so greatly facilitating and reducing the necessary hand labour. Provided the width of the top spit is made at least 12 inches, in order to give room for digging of second spit when necessary, the Excavator would be of material help where tile or stone draining is being undertaken.

Further trials of mole draining have confirmed the conclusion drawn from previous investigations that this form of drainage hasa very limited application in Northern Ireland.

Potatoes.—There is considerable evidence of an increase in the trade in seed potatoes from Northern Ireland and attention has been directed to the factors determining the relative proportions of ware and seed in the crop.

An investigation has been started by the Division to secure data under our local conditions as to the effect of size of seed tuber planted on the proportion of ware, seed and chats in the resultant crop.

Silage.—Increasing attention is being given to problems connected with the management of grassland throughout the United Kingdom. It is now realised that efficient grazing of the pastures or failing that, the mowing of the surplus grass is fundamental to good management. Under North of Ireland conditions there is often a surplus of grass and it is frequently not economically possible to stock the pastures to their full capacity. An experiment is being carried out by the Division in which this surplus grass has been mown and an attempt is being made to convert it into silage in portions of the farm buildings which have been converted into temporary silos.

General.—The Division is closely connected with the management of the Hillsborough Research Farm. A very detailed system of cost accounts is being kept of all branches of the farm and results of one financial year have now been obtained. As there are no data of this character available for Northern Ireland it is evident that the accumulation of such data will in time be of great assistance in the study of farm economics.

The internal reconstruction of some of the farm buildings and the erection of minor works at the Research Farm is being carried out by the farm staff. A record of the cost, etc., of these works is being kept by the Division and will be published in due time.

C.

HORTICULTURE
and
GLASSHOUSE CROPS.

12. LONG ASHTON FRUIT RESEARCH STATION, BRISTOL UNIVERSITY.

FRUIT CULTURE.

I. Plant Nutrition.

(a) Rootstock Problems.

Records have been continued on the trial plot of bush apple trees on selected layered stocks. Owing to adverse soil conditions it was necessary to replace the trees of the variety Lane's Prince Albert. The trees of Worcester Pearmain and James Grieve have made good growth.

Approximately 500 standard trees, mostly on the stronger of the selected layered stocks, but 50 on mixed seedling stocks and 20 on Hampshire Crab seedlings, were planted during the winter, 300 on arable ground and 200 in grass. The stocks have mostly been worked with scion varieties previous to planting—Worcester Pearmain, Newton Wonder, Blenheim Orange and Bramley's Seedling—but 56 are to be worked later. The experiment is designed to test the value of the various stocks for standard trees and will, of necessity, be continued over a long period.

Similar trees are being planted out in small batches in various parts of the West Midlands fruit areas as opportunity occurs.

Further records were obtained from the trees in the plantation of apples on the various " Paradise " stocks. The Worcester trees bore heavy crops and differences in quality due to the stocks were observed.

(b) Factors Determining the Relation of Growth and Fruit Bud Formation.

The respective activities of root, shoot and leaf are closely concerned with the process of fruit bud formation in trees. The following sections have direct bearing on this subject.

1. *Root and Scion Relations.*—Investigations relating to the effects of the scion on the rootstock have been continued. Special attention has been given to the technique of bench grafting and it has been found that the factors of callusing and elimination of mould growths during the callusing period are of great importance to successful propagation. The abnormally dry weather conditions which have occurred during spring in 1928 and 1929 have been very unfavourable to the growth of grafted stocks and have resulted in a large proportion of failures. The work is still in the preliminary stage.

Scion rooting in the trees of the initial stock scion experiment has now rendered further statistical results of little value from the point of view of the investigations originally planned. It has been possible, however, to make useful progress in the research on this subject from observations on groups of younger trees and the

problems of stock and scion interrelationships as affected by their relative growth vigour are being gradually elucidated.

2. *The Annual Shoot Growth curve of Apple Trees.*—Work on this subject has been suspended until certain points in relation to the periodicity of root growth have been elucidated (see following section).

3. *The Normal Seasonal Physiology of Fruit Trees.*—Arrangements have been made to follow in detail the nature and course of root development of the apple throughout the whole year in a somewhat similar way to the corresponding observations on black currants reported upon previously. The first year's cycle of growth has been determined and the observations are being extended over a further two or three year period, or longer as may be required.

The similar studies on black currants have now been completed, so far as the original series of cuttings is concerned. A further series will probably be started during the coming winter for certain supplementary information required.

4. *Biennial Bearing of Apples.*—The work has been continued along the lines mentioned in the last report. The treatments given are (*a*) deblossoming, (*b*) pruning in conjunction with the application of quick-acting nitrogenous manures, (*c*) thinning of blossoms and fruits. The effects of the treatments will not be apparent for two or three seasons.

5. *Ringing and Clamping.*—Bark ringing of the main stems of seven half standard apple trees of the variety Bramley's Seedling was carried out in May, 1928. Seven more trees were similarly treated in May, 1929. In each case the ringing treatment produced typical " ringing " effects on foliage and fruit during the season of the operation. The foliage and fruit of the trees " ringed " in 1928 were normal in appearance during 1929. As seven trees comparable with those above have been left " unringed," it has been possible to compare the effects of the two ringing operations with " unringed " trees during 1929.

The main effects observed were as follows :—

The trees " ringed " in May, 1928, blossomed three to four days later than those of the other two series.

" Ringing " in 1928 affected the amount of crop borne in 1929 in spite of severe frost damage.

Trees " ringed " May,	1928—	crop picked,	3,232	apples.
,, ,, ,,	1929—	,, ,,	1,075	,,
,, not " ringed "	—	,, ,,	965	,,

The growth habits of the trees have been affected. The heads of those " ringed " in 1928 are much more open than the " unringed " trees while those of the trees " ringed " in 1929 occupy an intermediate position between the above groups.

6. *Tree Shaping and Pruning.*—Work has been continued on the tree shaping plot. The pruning treatments are as under :—

(*a*) Regulated.

(*b*) Open centre, winter pruning only.

(*c*) Open centre, winter and summer pruning.

(*d*) Modified leader, winter pruned only.

(*e*) Modified leader, winter and summer pruned.

Summer pruning experiments on older trees have been continued. In the investigations in progress relating to the physiology of pruning responses, special attention has been paid to problems in relation to pruning, in connection with the shaping of trees and pruning for fruit bud formation. Pruning in the former instance is of great importance in relation to crotch splitting and the breaking of branches carrying heavy crops.

7. *Cover Crops.*—Very marked "grass effects" have been obtained in 1929 on the block of young apples seeded down in the autumn of 1928. The trees under the grass treatment carried pale yellowish green foliage, made relatively short extension growth, defoliated in advance of the trees on the cultivated areas and carried crops of extremely highly coloured fruits. In future years the effects of the grass treatment will be studied in conjunction with manurial treatments. The effects of the two systems on the moisture and nitrate contents of the soil are being examined.

(*c*) *Manurial Experiments.*

1. *Pot Experiments.*—The experiments relating to fruit quality mentioned in the last report were continued. Crops were obtained in all cases and these are being utilised for chemical and storage experiments. The various deficiency treatments produced the typical effects recorded on previous occasions.

The experiment in which apple trees have been grown in sand under deficiency treatments for the purpose of chemical studies on the effects of deficiencies of potassium, calcium, and magnesium on the composition of various parts of the trees have been concluded. A report is in the press.

2. *Laboratory Work.*—Investigations were continued on the following points :—

(*a*) The composition of the leaves and shoots of three varieties of apples—Bramley, Worcester and Allington—growing under conditions of deficiencies of nitrogen, potassium, phosphorus, calcium and magnesium respectively.

(*b*) The effects of various soil conditions in the Evesham and Pershore Soil Survey areas on the composition of the leaves and terminal shoots of two varieties of gooseberries—Whinham's Industry and Careless.

(*c*) The composition of the foliage of Worcester Pearmain apple trees on Malling types I and V rootstocks growing under the two treatments. (i) unmanured since planting, (ii) complete manure each spring since planting.

The investigation of the effects of deficiencies of potassium, calcium and magnesium on the mineral content of the leaves, terminal shoots and main stems of apple trees, var. Stirling Castle, growing in sand in pots, was completed. The respective deficiency treatments are reflected in the composition of the ash of all parts of the trees examined.

3. *Field Experiments.*—Field experiments, as outlined in previous reports, have been continued. On the Research Station plots, potash deficiency effects are the outstanding feature with all fruits tested—apples, gooseberries, black currants and strawberries. In the last named case the results have been largely vitiated by the prevalent strawberry diseases.

In experiments in which the treatment " grass plus nitrate of soda " is given to apple trees, it is evident that a spring dressing of nitrate of soda greater than 5 cwts. per acre is required to overcome the nitrogen starvation due to the sod treatment.

(*d*) *Soil Moisture Experiments.*

Soil moisture experiments on apple trees in pots, variety, Bramley, were continued. This was the first season of differential treatments.

The Wet series were grown with the soil moisture regulated to near the point of soil saturation and the Dry series with the moisture content slightly above wilting point.

The " Wet " trees made vigorous growth and produced crops of extremely large fruits. In the case of the " Dry " trees the blossom trusses and spur leaves dried out and were shed, and it appeared that the treatment affected spur growths more severely than shoot growths. In view of this, it would appear to be impossible to obtain a crop under the dry conditions. The foliage symptom in the case of the Dry series was marginal Leaf Scorch.

The crop from the " Wet " trees is being utilised for chemical and storage experiments.

(*e*) *Leaf Scorch.*

Pot and Laboratory Experiments.

1. *Waterlogging Experiments.*—The investigations have been continued. In the first series of gooseberry bushes examined, waterlogging did not produce significant effects on the mineral composition of the leaves and stems of the terminal shoots.

2. *Rootstock and Scion Effects in Leaf Scorch on Apples.*—Apple trees of the variety Cox's Orange Pippin on the rootstocks Malling

types I, II, V, and XII are being raised in the nursery for sand culture experiments, using large containers, to determine rootstock influences.

3. *Chemistry of Leaves, Stems and Fruits in cases of Leaf Scorch.*—Further results support the findings outlined in the last report.

Work on minerals, nitrogen and carbohydrate materials in gooseberry bushes in cases of leaf scorch is in progress. The main source of material is the Station manurial plot.

In connection with field experiments on the use of potash manures in controlling Leaf Scorch, the manurial effects produced are being followed by chemical studies on the experimental materials. An attempt is being made to correlate observed responses with increased potassium content of the various parts of the trees.

The potassium contents of varieties resistant to Leaf Scorch, growing on " Scorching " areas, have been compared with those of comparable susceptible varieties. The resistant varieties contained slightly more potassium than the susceptible ones in such cases but were decidedly low in potassium.

Field Investigations.

4. *Investigations on the Relation between Soil conditions and the occurrence of Leaf Scorch.*—These have been continued to confirm previous findings.

5. *Field Experiments with Potash Manures and Lime in Controlling Leaf Scorch.*—Potash manures continue to give striking results at most centres.

Lime where tested on gooseberry bushes on an extremely acid soil has not produced observable effects after three years whereas sulphate of potash has effected marked improvements.

6. *Spraying Experiments with Sulphate of Potash.*—In certain cases where heavy dressings of potash manures over three or four seasons have failed to produce appreciable effects on Leaf Scorch, certain of the trees on the manurial plots have been sprayed at intervals of one week to two weeks throughout the growing season with a 1 per cent. solution of K_2SO_4. Very pronounced beneficial effects from the spraying treatments were produced at two centres—one on plums and one on apples.

The results indicate that the poor effects obtained from manuring with potash are largely due to the failure of the trees to obtain the manures easily from the soils in question.

(f) The Effect of Leaching with Cold Water on the Foliage of Fruit Plants.

The rates of the leaching of dry matter, ash and potash, from the leaves of four varieties of apples, plums, pears, black currants and gooseberries by means of immersion in cold water have been compared. The various classes of fruits and the individual varieties show considerable differences in the rates of leaching.

(*g*) *Lime-induced Chlorosis of Fruit Trees.*

Further observations have been made on the effects of cover crops in controlling this type of chlorosis. Cover-cropping continues to give effective control in the cases considered.

An anatomical investigation has been commenced in which the mobility of certain substances within the stems of chlorotic trees will be examined.

(*h*) *Nutritional Characters affecting Fruit Quality.*

Attention is being given to various points affecting the nutrition of trees in relation to their effects on fruit quality and, in particular, on storage qualities. The more important factors under examination are : deficiencies of the essential elements, nitrogen, potassium, calcium, magnesium and phosphorus ; soil moisture ; high and low nitrogen feeding ; systems of manuring ; cultural operations ; age of trees ; rootstock effects ; bark ringing ; systems of pruning ; thinning of blossoms and fruits ; time of picking.

Important results are indicated but confirmation over further seasons is required before definite conclusions may be drawn.

(*i*) *Subsoiling Experiments.*

Subsoiling experiments, using a tractor fitted with a special subsoiling tool, have been commenced at four centres.

At two of the centres a special type of impervious silty subsoil has been treated, at another an iron pan area in a light gravel—coarse sand type soil has been broken up and at the fourth the object of the operation has been merely to provide greater soil depth. The effects on future fruit and other horticultural crops will be observed.

II. Surveys of Fruit Soils.

The field work on soils and pomology in the areas around Pershore and Evesham is well advanced. Further pomological studies have served to substantiate the previous findings relative to the close correlations which exist between soil conditions and growth characters of the trees.

III. Special Investigations on Soft Fruits.

Strawberries.

Strawberry problems have not received as much attention as during the few previous years, owing to pressure of other work, though the various investigations outlined in the previous reports have been continued.

(*a*) *Strain Trials.*—These have been continued.

(*b*) *Botanical Classification.*—This has been continued and a preliminary report has been published. In the Station collection of varieties, only a few remain in a vigorous healthy condition.

(*c*) *Abnormal Forms of Strawberry Plants.*—The field studies on the classification and production of the various "abnormal" forms have been continued.

(*d*) *Anatomical Investigations on the Roots and Crowns of the Strawberry Plant.*—The work has been continued.

(*e*) *Nutritional Experiments.*—Field experiments described in previous reports have been continued (Section I (*c*) of this report). The third successive planting on the Station plots was carried out in the autumn of 1929.

(*f*) *Insect Pests, etc.*—(Sections IX, X and XI of this report).

(*g*) *Fungus Diseases.*—(Section XIX of this report).

(*h*) *"Red Plant" and "Cauliflower."*—Work has been continued on the relationship between the above diseases and strawberry eelworm. Since eelworms are found in both healthy and "red" plants, an attempt is being made to correlate eelworm numbers with degrees of "redness." Most attention has been given to the development of a suitable technique for the studies.

(*i*) *"Small Leaf" Form produced by Red Spider.*—(See Section X of this report).

Raspberries.

(*a*) The cropping trials of selected varieties have been continued and further varieties have been added. An interim report on the initial batch of varieties tested is in course of preparation.

(*b*) *Raspberry Diseases.*—(Section XVIII of this report).

Currants.

(*a*) *Propagation.*—Field experiments with black currant cuttings carried out over two seasons have shown that the order of vigour of the resultant nursery plants bears no simple relationship to the time of planting of the cuttings. Physiological examination appears necessary in such experiments and further field work will be carried out in co-operation with physiological studies.

(*b*) *Nutritional Experiments.*—(Section I (*c*) of this report).

(*c*) *Red Currant Classification.*—The collection and classification of varieties have been continued. Clone material for trial is being propagated.

Gooseberries.

(*a*) *Classification.*—The classification of varieties has been continued. Clone material of several dessert and green varieties will be planted out this winter for cropping trials.

(*b*) *Nutritional Experiments.*—(Section I (*c*) of this report).

IV. Fruit Breeding.

Fruit has been obtained from approximately 600 seedling apples, 50 pears and 75 plums. Ten varieties of dessert apples, ranging

in season from August to December, have been selected for further trial. Several pears of good quality are under consideration for further tests. Fifteen plums of high dessert quality, among which some are really of first class quality and some of very late season have been selected.

A trial plantation of 3,500 bushes of selected seedling black currants, usually 72 bushes per seedling, has been planted out for an extensive trial of the best seedlings so far obtained.

Raspberry seedling trials are still in the early stages.

The strawberry seedlings mentioned in the last report bore good crops in 1929. Many carried excellent crops of good quality fruit and a large number are vigorous and appear resistant to aphis attack.

Further pollinations for seed production of apples, plums, black currants and strawberries have been carried out.

V. Pollination Studies.

The trials of the self-fertility of certain varieties of cider apples were repeated for the third successive season. The results are in accord with previous years.

PESTS AND DISEASES AND THEIR CONTROL.

VI. Reversion Disease of Black Currants.

Observations on the field plot were continued. No significant point has emerged to date.

VII. "Big Bud" of Black Currants.

The relation between "Big Bud" and Reversion is being followed on the plot referred to in Section VI. The pest has not been so far observed on the plot.

The action of Sulphur in particulate form against the Big Bud mite has been tested on some heavily infested bushes. No conclusions can be drawn to date.

VIII. Manurial Trials with reference to susceptibility to Insect Attack.

This work has been continued.

IX. Strawberry Aphis.

Further work on this pest is suspended pending arrangements being made for experiments with dusts.

X. Red Spider (*Tetranychus telarius*).

Field investigations have shown that Red Spider is a serious pest of strawberries. Infestations of this pest result in a "small leaf" type of plant.

XI. *Harpalus ruficornis* and other species of Carabid Beetles attacking Strawberries.

Investigations relating to the life histories, bionomics and control of Carabid beetles were carried out in the Cheddar strawberry area.

Considerable data were collected in relation to the first two points.

Whizzed Napthalene and Sodium Fluosilicate were tested as control substances. The results were inconclusive owing to the slight degrees of infestations.

XII. Control of Capsid Bugs.

Extensive field trials—apples (11 centres), plums (3 centres) and black currants (3 centres)—with a "High Neutral" tar oil wash, prepared according to the Long Ashton formula (two-solution wash) and a one-solution wash, containing the same High Neutral tar oil but a different emulsifier from the Long Ashton wash, were carried out in all the important fruit growing areas in the country.

The Long Ashton wash, at 10 per cent. strength, effected a commercial control of the Capsid Bug (*Plesiocorus rugicollis*) on apples at all centres excepting one and proved definitely superior to the older type of tar-oil wash in controlling capsids and caterpillars.

XIII. Pear Midge (*Contarinia pyrivora*).

The treatments described in the last report were again tested against the pest but the results were inconclusive owing to scarcity of the pest and to climatic conditions.

XIV. The Control of *Byturus tomentosus* on Raspberry and Loganberry.

Field trials on the control of this beetle were carried out on Raspberries and Loganberries with the Pyrethrum-oil spray described by F. Tutin in the Station Report, 1928, p. 96. Three applications were given at each centre and a considerable degree of control was effected in all cases. A report is in course of preparation.

XV. Woolly Aphis.

An attempt to control this pest by means of *Aphelinus mali* in an orchard near Bristol has failed up to the present owing to the failure of the parasite to establish itself.

Further experiments, using nicotine with Agral I as a spreader, against Woolly Aphis were carried out on nursery stocks. Satisfactory control was obtained.

XVI. Pests on Nursery Stock.

Experiments on the control of various pests on nursery stock have been commenced. Attention has been given to the control of Woolly Aphis and "Big Bud" mite. The amount of material

available was not large Control of Woolly Aphis was effected by dipping the stocks in a 10 per cent. solution of Tar-oil wash.

XVII. Plum Die-Back.

The experimental plot at Long Ashton remains free from Die-Back.

Work on the incidence and progress of bark cankers is being carried out in the Evesham area.

A study has been made of the various forms of Die-Back occurring in the Pershore-Evesham soil survey areas. Three classes of Die-Back are distinguished, viz :

(1) Die-Back of young trees following infections with bacterial canker and apparently not related to any soil factor.

(2) Dying out of mature trees associated with slow rotting of the interior of the trunk on light soils and attributed primarily to soil conditions.

(3) Death of mature trees on clay soils, the causes of which are still obscure.

XVIII. Raspberry Diseases.

Investigations on the spread and control of Mosaic have been continued. Strict " rogueing " measures have proved very effective in keeping Mosaic in check.

It is of interest to note that raspberry mildew was very prevalent although the weather was abnormally dry.

XIX. Strawberry Diseases.

Experiments have been continued with a view to determining whether " red " plant and " aphis " plant diseases of the strawberry belong to the category of virus diseases. So far results are of a negative character.

XX. Collar Rots.

The incidence of these rots is under observation and methods of control by means of soil fungicides are being investigated.

XXI. Phytopthora Rot of Apples and Pears.

Since this disease is assuming serious proportions in the south-west of England, the life-history and control of the causative fungus are being investigated.

XXII. Plum Rust (*Puccinia pruni-spinosae*).

Investigations on the methods of overwintering and control of the fungus have been continued.

XXIII. Black Currant Leaf Spot (*Pseudopeziza ribes*).

Experiments to determine the method of overwintering of the fungus have been continued.

A commercial control of the disease can be obtained by applying a Bordeaux spray immediately after removal of the crop. Such a spray applied in 1928 prevented premature defoliation, increased the average bud weight by 15·3 per cent. and resulted in an increased crop of 26 per cent. in 1929.

Treatment with copper-lime dusts proved ineffective.

XXIV. Black Currant and White Pine Rust (*Cronartium ribicola*).

In pot experiments with a view to determining whether the fungus overwinters on the black currant, the results obtained were purely of a negative character.

XXV. American Gooseberry Mildew.

Dusting with sulphur has proved an efficient means of control and the method has been widely adopted by growers with complete success. Further work will be in relation to susceptibility of various varieties to sulphur damage.

XXVI. Apple Scab.

Investigations relating to spray damage were continued and the costs of spray applications have been determined on the Research Station plots both on bush and standard trees. Excellent control of the disease has been obtained with Bordeaux mixture—two pre- and one post-blossom application—but marked russetting followed the use of post-blossom applications of Bordeaux on the varieties James Grieve and Lane's Prince Albert.

Serious defoliation resulted from sulphur sprays—lime sulphur and colloidal sulphur—on Stirling Castle and Lane's Prince Albert.

The pot experiments to determine the relation between Scab susceptibility and deficiencies of nitrogen, phosphorus, potassium, calcium and magnesium were continued. In addition to the nutritional factor, the influence of several other factors on varietal resistance to Scab has been closely investigated during the year and it is hoped to have the results ready for publication at an early date.

XXVII. Apple Mildew.

No satisfactory control of this disease exists. Field experiments using various materials have been commenced but the effects of the treatments will not be apparent until 1930.

XXVIII. Tar Distillate Winter Washes.

The high boiling point neutral tar-oil wash prepared in accordance with the Long Ashton formula has given effective control of Capsid Bug on apples in extensive field trials.

The toxic action of individual constituents of the high boiling neutral tar-distillate on the eggs of the winter moth has been examined. None of these has been found to be more efficient in

this respect that the "high neutral" fraction previously recommended.

The destruction of the eggs appears to depend chiefly on covering them with an impervious non-volatile oily coating which is not removed by rain. Toxic action due to the chemical nature of the material appears to play only a minor part but is important in the case of eggs of *aphis* and *psylla*.

XXIX. Pyrethrum Spray Liquids.

Experiments with the spray fluid previously described have been continued. (For field trials against *Byturus tomentosus*, see Section XIV of this report). The material is also effective in controlling Red Spider and the Willow Beetles, being vastly superior to nicotine for the latter purpose. The entire activity of Pyrethrum flowers resides in the petroleum-soluble constituents, the ethereal, alcoholic and aqueous extracts, subsequent to extraction with petroleum, being innocuous.

XXX. *Inula dissenterica.*

The flowers of this plant have been examined for the presence of substances of insecticidal value but with negative results.

XXXI. *Oenanthe Crocata.*

The toxic principle contained in the tuberous roots of this plant, when dissolved in fatty oil, possesses decided insecticidal properties. The constituents of the above-ground portions of the plant are also under examination.

XXXII. Wetting Powers of Fungicides.

The high efficiency of Agral I as a wetting agent is being utilised in sprays against apple mildew.

XXXIII. The Fungicidal Action of Sulphur.

The experiments previously recorded relative to the interaction of sulphur with fungus spores and host plants in connection with the toxicity of sulphur to various fungi have been continued.

The mode of natural dispersion of sulphur and its relation to the germination of fungus spores are being further examined.

Investigations on the nature of the interaction between the living organism and sulphur, the reacting substance produced by the plant and the conditions affecting its discharge, are being continued as actively as circumstances permit.

FRUIT PRESERVATION AND PRODUCTS.

XXXIV. The Chemistry of Apples.

The investigations on the effects of nutritional factors on the composition of fruits have been continued.

The contents of nitrogenous, carbohydrate and ash constituents can be materially altered by various nutritional factors such as manuring, pruning, thinning, ringing, cultural practices, etc.

These factors also affect the storage life of the fruits.

In examining the water insoluble constituents of apples, two crystalline bodies of a phenolic nature have been isolated.

XXXV. The Physiology of Fruits.

The growth and composition of gooseberries under conditions of potassium deficiency are being compared with those of fruits receiving adequate potassium.

The development of the apple in relation to manurial treatment, position on the tree, etc., is under examination. This work is linked up with studies on storage quality.

The storage properties of apples in relation to differences in maturity due to various factors are under investigation. The work has special reference to the functional troubles of Bitter Pit and Internal Breakdown and to various nutritional factors.

Histological and cytological studies in connection with various storage breakdowns have been continued.

XXXVI. Cider Investigations.

(a) *Cider and Perry Variety Competitions.*—These competitions were continued. There were 176 entries.

(b) *The Use of Sulphur Dioxide as a Cider Preservative.*—Sulphur dioxide, applied either in the liquid form of potassium metabisulphite, was found to check the rate of fermentation most when added immediately after the first racking.

The action of SO_2 on the cider-sickness bacillus was also studied.

(c) *Cider Storage Trials.*—Ciders were kept in cold store (at 1°C.), examined at intervals, and compared with controls kept at ordinary cellar temperatures. The cold storage samples showed less deposit on keeping and had a fresher and more aromatic flavour after six months than those kept in the cellar. The flavour of "old cider" typical of many varieties after storage, especially bittersweet varieties, was absent from the cold stored samples.

(d) *Investigations on Metals Resistant to the action of Cider.*—Several so-called "cider metals" proposed for use for cider casks were tested and found to be totally unsuited for the purpose.

(e) *The Filtration of Cider.*—The filter mentioned in the last report was tested and found to yield germ-free cider when certain precautions were taken. This filter should prove of value in obtaining deposit-free bottling ciders.

(f) *The Maturing of Cider in Bottle.*—The investigations have been continued. No fresh significant results have been obtained.

(g) *Apple Juice Conservation and Concentration.*—These experiments were continued. In concentrating apple juice the temperature

should not exceed 45° C. if a light coloured juice of high aroma is to be produced. The specific gravity should not be less than 1·30, corresponding to 62 per cent. of solids, or the concentrate does not keep well. The addition of 10-15 per cent. of a mixture of equal parts of sucrose and glucose syrup either before or after concentration improves the consistency of the concentrate.

(h) *Cider Sickness.*—(See Section XXXVI b.)

WILLOW CULTURE AND THE UTILISATION OF WILLOWS.

Variety Trial Plots.—Arrangements have been made for considerable extension of the area hitherto devoted to this branch of the work in order to obtain sufficient "set" material of the selected new varieties for more extensive trials. This additional land when planted will also enable experimental work on methods of commercial crop management to be undertaken.

The new varieties raised in 1928 by controlled methods of breeding (*see* 1928 Report) were planted in beds. Selections will be made from these plants after their characters have been more fully investigated.

Attempts to hybridise *Salix triandra* and *S. viminalis* made in the spring of 1929 were unsuccessful.

Acropetal Value of Sets.—The relative values of sets taken in acropetal order from a number of similar rods were investigated. The results from the first year's crop showed :—

(1) The sets consisting of the two uppermost segments produced lower yields of rods than the lower segments.

(2) The yields of rods considered in relation to the weight of set planted were greater in the case of the two upper segments.

Treatment of Willow Pests.

(a) *Insect.*—The behaviour of the willow beetle, *Phyllodecta*, was studied in detail in collaboration with the Entomologist of the University of Bristol. Information was obtained on :—

(i) varieties of willows resistant and susceptible to attack.

(ii) methods of control in which nicotine, lead arsenate and pyrethrum preparations were used.

(b) *Fungus.*—Bordeaux mixtures of different strengths and in different forms were tested in their effects in controlling attacks of the fungus *Melampsora*. The objection to the use of this preparation in the powder form was the difficulty in getting adhesion to the plant.

Investigations on the biology of willow rusts have been continued.

Identification of Salix alba, var. Caerulea (*Cricket-bat Willow*).—Cuttings of Cricket-bat willow from four different sources were planted in proximity in order to compare their characters. Growth results showed three of these to be similar but not identical ; the other was different from the rest.

Effects of removing side shoots.—Lateral shoots were (*a*) cut off close to the stem, (*b*) twisted at the base, (*c*) pulled off, with the object of ascertaining the value of the treated rod for commercial purposes. The objection to this practice was found to be that permanent scars are formed on the rod at the places at which side shoots are removed, but a rod so pruned could be used in basket-making.

The Checking of Lateral Branching.—Salix hippophaefolia is subject to side shooting when grown under the usual field conditions. Sets 2 ft. 9 ins. in length were planted leaving 2 ft. of the rods above ground level. Numerous shoots were developed from ground level to the apex of these sets. The crop was smooth but the rods were shorter than those produced from cuttings planted in the usual way.

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13. EAST MALLING RESEARCH STATION.

I. POMOLOGY.

A. In relation to Tree Fruits.

(a) *Rootstock Investigations.*

1. *Stocks for Apples.*—In the tenth year, trees on nearly all varieties of rootstock bore considerable crops, the detailed recording of which is providing valuable data from which to deduce the suitability of different combinations of stock and scion for particular purposes and schemes of planting. A general review of these investigations has demonstrated the extent to which particular scion varieties, soil and manurial conditions may modify any general grouping of stocks. On the other hand, rootstock influence is becoming accentuated with the age of the tree.

2. *Stocks for Pears.*—The behaviour of trees on a range of Quince Stocks has been reported upon. The trees on vegetatively raised Free Pear Stocks are already showing differences in growth.

3. *Stocks for Plums and Peaches.*—A full report on the behaviour of Hales Early Peach upon series of nursery trees, trees grown in pots under glass, and fan trained trees in the open is in course of preparation. " Incompatibilities " in the nursery are not infrequent ; the fruiting capacity of the pot trees has been obviously affected by rootstock, whilst striking differences in vegetative features have appeared in the fan trained trees.

4. *Stocks for Cherries.—Sweet Cherries* (*P. Avium*). Root stock influence on the scion has in the past year become more marked in at least one direction—that of susceptibility to disease (Bacterial Die-back). One particular variety used as a stock is itself highly susceptible, and appears also to make the scion more susceptible to this disease. The field orchard of Standard trees of three varieties of cherry on different layered stocks has been planted out on 6 acres.

Acid Cherries (*P. Cerasus*).—A heavy crop of fruit of Morello has indicated that the root stock may to some extent influence the amount of fruit borne, its size, and perhaps its time of ripening. A younger series of trees is beginning to show considerable stock influence on vigour of growth.

(b) *Analysis of Rootstock Influence and the Reciprocal Effect of Scion upon Root.*

The series of bench grafted trees referred to in the last report have made excellent growth during the season, and a number of them will be lifted for examination of the root characters during the present winter. The remainder will be left *in situ* to see whether these trees—grafted on to piece roots—all stock stem having been eliminated—manifest any signs of rootstock influence. All scion rooting has been successfully prevented.

(*c*) *Root Excavations.*

A preliminary report of this work has been published. With an improved technique, the operations were continued during the year, five 11-year old Lanes Prince Albert apple trees on a series of known rootstocks at East Malling (Hythe Beds) and thirteen 10-year olds on the Bagshot sands at Wisley being excavated. It was thus possible to compare the behaviour of the same rootstocks under very different soil conditions. The ratio of root to branch weight differs greatly according to the soil type. Thus whilst the weight of roots was about equal at Wisley, it was about half at East Malling. The vigour of growth does not necessarily depend upon depth of rooting, which varied greatly according to local conditions.

The actual growth of the roots is obviously greatly affected by various soil factors such as texture, moisture, aeration, etc. However, both on the loam and sand the type of root system of the different stocks was so distinctive that there was little possibility of mistaking their general characteristics. The records are still under review and the work is being developed.

From a practical point of view, it was instructive to find that the fine fibrous absorbing roots were fairly evenly distributed over the whole root spread—not just around the trunk where a mulch is so often applied. The spread of roots was often more than twice the spread of branches.

(*d*) *Double working.*

Apples and Pears.—The effect of the use of an intermediate scion between the rootstock and the scion forming the head of the tree, has been under investigation with apples and pears for ten years. There seems definite evidence of an influence of the intermediate on vigour of growth, in one case so pronounced as to suggest partial incompatibility ; there may also be an influence on fruit colour, and probably in some cases on precocity and perhaps time of ripening.

It also appears that the length of the intermediate affects the result. A longer piece of stem of the variety used as intermediate has more influence (in the same direction) than a shorter piece. The data so far collected are now being analysed.

(*e*) *Pruning Experiments.*

(i) *Apples.*—The trees have now passed beyond the early stages when such details as length of spurring affect the results. The main problems now are the maintenance of fruit quality and the restriction of the trees to reasonable size.

(ii) *Pears.*—Most of the twelve varieties worked on quince roots, which have now been subjected to various methods of pruning for five years, bore their first considerable crop in 1929. Even at this early stage the effects upon size and quality of fruit are apparent.

(*f*) *Manuring of Apples.*

(i) *Potash.*—The drought of the past summer resulted in severe leaf scorch even on the potash treated plot. It appears likely that several more annual dressings of potash must be given, or at least that several years more must elapse before the treated trees are able to resist severe drought conditions. The difference between the treated and untreated plots was nevertheless considerable ; two or three of the few previous exceptions have now fallen into line with the majority and clearly show the beneficial effects of potash feeding.

(ii) *General.*—The indications described in the last report that the withholding of manures from young apple trees was becoming evident by the eighth year, were strikingly intensified by the heavy crops of fruit borne both on the manured and unmanured plots in the current season. Not only were the size, colour and quality of the fruit grown under starved conditions manifestly inferior, but the trees indicated both in foliage and growth that some immediate remedial treatment would be necessary. The trees are now ten years old, and demonstrate that, at any rate under conditions such as prevail at East Malling, systematic feeding is essential for the growing of good trees and fruit.

At the same time there is a marked difference in the response of the same varieties upon different rootstocks to conditions of starvation or complete balance.

(*g*) *Fruit Breeding.*

(i) *Rootstocks.*—In collaboration with the John Innes Institution the comprehensive programme of crosses between different varieties of apple rootstocks, with a view both of raising Woolly Aphis immune stocks and also securing a more complete range of root system is proceeding according to plan. Some of these new stocks have now been vegetatively multiplied in sufficient quantity to permit of preliminary testing. Similar work is proceeding in the case of plum rootstocks, ready vegetative propagation being here one of the characters sought.

(ii) *Varieties.*—The first batch of seedlings, raised from crosses in 1928, with the object of obtaining a succession of highly-coloured good flavoured dessert apples, are ready for planting out.

Further observations made during the past season relative to the possibility of hastening the cropping period of such seedlings by the use of dwarfing rootstocks confirmed the report already published that this appears likely.

(*h*) *Fruit Soil Survey of Lower Greensand in Kent.*

During the course of the first year the pomological staff (in working collaboration with the soil chemist at the S.E.A. College, Wye), made a field to field survey of an area between Egerton and West Peckham of approximately 2,275 acres. An " average " standard of tree vigour has been arrived at, and one of the striking facts would appear to be the relative importance of the influence of good and bad cultural treatments upon the tree's behaviour as compared with anything but extreme soil variations.

(*j*) *Walnuts.*

Successful methods for propagating young walnut trees under glass true to variety, have been reported upon. Experiments in outdoor budding and grafting have been continued.

Methods of layering in the open ground have been tested in the hope of standardizing the rootstock as well as the scion. Considerable success has been obtained in rooting young shoots of selected *Juglans regia, J. nigra, J. cinerea, J. Sieboldiana* and the hybrids *J. Paradox* and *Royal* during the past season.

(*k*) *Pyrethrum.*

A number of plants from seedlings of Japanese origin have been selected for their vigour and bloom production, and are being multiplied vegetatively. The flowers from the resulting clone races will be tested for their comparative toxic value.

B.—In relation to Bush Fruits.

(*a*) *Currants.*

The variety trials are being continued, and the question of nomenclature followed up. A report on means of distinguishing the " rogue " varieties circulating as " Baldwin Black " is in preparation. *The genetic studies* are being considerably developed, the idea of inter-species crossing as a means of improving existing varieties being tested. A paper on the genetic constitution of the main groups of Black Currant has been prepared, and whilst showing that most varieties when selfed breed comparatively true, it throws light upon the relationship of the different sorts comprised in the French Seabrook Group.

The Manurial Trials, probably as a result of two exceptionally dry summers, and comparatively poor crops of black currants, have so far yielded no significant responses to the different times and applications of nitrogen.

(b) Raspberries.

Variety trials, etc.—A successful beginning has been made in the attempt to raise mosaic disease free stocks of a number of commercial varieties.

Manurial trials upon the varieties Lloyd George and Pyne's Royal are being continued but it will be some seasons yet before any safe interpretation can be placed upon the results. Cane measurements as well as fruit weights are being recorded.

(c) Strawberries.

Strain and Time of Planting.—Detailed crop records were taken on the three acres of Royal Sovereign strawberries planted 1927-8. These showed that although the performance of the plants from different sources has been evened up considerably by the elimination of bad plants, one " strain " cropped significantly worse than the other two. It is interesting to note, however, that the selected progeny of these parents, planted 1928-9, show no significant differences between the three " strains " in their first year's crop. It would appear that the drastic roguing given to the parents, with careful selection of the runners, has practically eliminated the original differences between these so-called " strains."

Besides crop records on the " strain " and " time of planting " trials (planted 1928-9), a complete plant to plant survey was made in August, including measurement of size of plant. These records reveal significant differences between different times of planting, both in vigour and cropping. The August, 1928 planting was a failure, owing to the dry conditions following. It was again impossible to plant in August, 1929, owing to drought. The October planting gave very satisfactory results, but each successive planting afterwards was progressively less vigorous. It seems obvious that the weather conditions prevailing in each locality and not the calendar, must be the guide as to the optimum planting season. A suggestive point is raised by the fact that the runners planted in March, 1929, cropped more heavily than those planted in December, 1928 (which had made more growth), thus showing that under certain conditions cropping of strawberry plants does not vary proportionately to their size.

Statistics and Records.

A considerable portion of the year's work has been devoted to the lengthy task of summarising back records in such a way that their analysis may be proceeded with, and it is now possible to review the performance of the trees on all the major trials. Sufficient light has now been shed upon the problem of the relationship between the

different manifestations of such tree characteristics as vigour and cropping, to show the exceedingly complex nature of the problem.

It is apparent that as one measure can possibly give a complete picture of the vigour of a tree at any one time and trial the measurements to be taken must depend upon the nature and purpose of the experiment.

In the meantime the rapid increase in size of trees to say nothing of heavy crops, have made labour-saving schemes an imperative necessity. In consequence, a number of sampling methods are being tried out. Although it is very difficult to sample a tree for such quantitative characters as actual growth or fruiting, it seems probable that a very good idea of such qualitative characters as size of fruit, stoutness of wood, etc., may be obtained in this way.

The more intimate knowledge gained as a result of careful analysis of the records upon material of known history has facilitated the progress of plot planning work and the better organization of recording.

II. PHYSIOLOGY.

Vegetative Propagation.

Trials have been continued of the influence of external conditions upon the rooting of cuttings of varieties difficult to propagate. Attention is still being concentrated on soil and atmospheric moisture and although preliminary experiments with shelters have not given good results, closer regulation of soil moisture is promising.

Influence of Rootstock on Leaf Relations of Apple Trees.

The weekly increase in leaf area of maiden trees of Worcester Pearmain on the four stocks I, II, IX and XII has been investigated, and this work will be continued and extended next year.

In this investigation the smaller leaves were measured by the method of standard forms described in last year's report. A new method has been developed and used for the measurement of larger leaves with greater speed and without loss of accuracy. The leaf is gripped under a sheet of glass ruled in squares (·5 cm.)^2. By counting the number of squares in the portion of the glass directly over the leaf, the area of the leaf can be determined with a reasonable degree of accuracy.

Growth.

Stem Diameter and New Shoot Growth.—A report on this subject is ready for publication. It has been shown how the differences in stem diameter of plants subjected to different methods of pruning are arrived at, the amount of increase in diameter depending on proximity to growing shoots and apparently also upon the type of shoot-growth made.

Seasonal Course of Root and Shoot Development in Apple Stocks.

Although considerable knowledge has accumulated as to the total amount of stem growth made during the year by fruit trees, little is

known as yet about the variations in this rate of growth at different seasons of the year, or of the effect of local climatic conditions upon this rate. With regard to root growth still less is known. It is not known for certain at what season the roots grow fastest, at what time they become dormant, how long they remain dormant, or indeed, if they become completely dormant at all.

A knowledge of the seasons of maximum and minimum growth and of their relation to local climatic conditions will obviously be of value in connection with all fruit studies.

To fill this gap in our knowledge, preliminary investigations have been begun this year on one year old trees of Stock No. XIII. Samples of trees have been harvested at intervals of about a month, from spring onwards, and the increments in weight of the various organs determined by taking the dry weights of the leaves, shoots and roots.

This work will be continued, and will be extended to older trees.

Excavation of Root Systems.

In collaboration with the Pomological Department, the investigation of the root system of older trees has been continued. For full report see Pomological Section.

III. BIOCHEMISTRY.

Stock Influence.—During the past year the spectrographic survey of the elements occurring in apple tree ash has been somewhat extended and progress has been made with an analytical method which it is hoped will be applicable to most of them.

Elements so far detected by spectrographic means, arranged roughly in order of the intensity of their lines are :—Calcium, magnesium, potassium, sodium, aluminium, iron, manganese, silicon, strontium, barium, lead, lithium, copper, vanadium, nickel, titanium, chromium, tin, molybdenum, silver.

Reference was made in the last year's report to the fact that though most of these elements appeared to be more or less uniformly distributed throughout the tissues of the plant, certain of them, in young trees, at least, were more abundant in the lower than in the higher woody parts. Thus the minute amount of lead detected seemed to be restricted to the root wood and the aluminium lines became weaker as the woody parts were ascended. To them must now be added molybdenum which has been detected in woody parts of stock No. IX below graft level but which appeared to be absent from all parts above graft level, and also from the bark below graft level.

As far as can be judged from analyses of the roots of ten trees on stock No. XII and nine trees on stock No. IX, growing in two parallel rows, this element was absent from stock XII and was probably a fairly constant constituent of stock IX. Any more definite conclusion must await the perfecting of the quantitative

method, for technical difficulties in the spectrographic method when applied to molybdenum render it unsuitable for the further examination of the distribution of this element, especially in view of the small amounts of material available.

The results of the spectrographic tests as a whole suggest that there are sufficient differences in distribution of the ash constituents, particularly those occurring in minute amount, both when different parts of the same tree, and when corresponding parts of different stocks, are compared, to justify a careful study of them by quantitative methods.

It is hoped that most of the technical difficulties inherent in the physico-chemical method, which is being adapted for the quantitative determination of most of the ash constituents, have now been overcome and that the method will be yielding results early in the New Year.

Insecticidal and Fungicidal Action of Sulphur.—As a result of work carried out at Rothamsted, thiosulphuric acid was suggested as the compound most likely to be responsible for the fungicidal action of sulphur towards Wart Disease of potatoes, but the existence of this acid in a free state is commonly denied. Recently, modifications of the methods of others have led to a proof of the existence of thiosulphuric acid in a free state and experiments defining its degree of stability have been carried out. The facts obtained support the idea that thiosulphuric acid was the cause of the toxicities both of a series of solutions tested in the laboratory and of sulphur in the field.

An opportunity of extending this work to other fungi in the laboratory has not yet arisen and preliminary tests in the field carried out in collaboration with the mycological section have so far yielded inconclusive results.

Arising out of observations made some years ago attempts have been made, in collaboration with the entomological section, to increase the efficiency of methods of application of elementary sulphur. Working with red spider, it has been found possible to reduce considerably the amount of sulphur, and the relatively resistant greenhouse red spider has been killed on Leveller gooseberry (perhaps the most sensitive variety to sulphur injury) without causing leaf drop. The results hold out some hope of eventual practical applications.

PLANT PATHOLOGY.

IV. Mycology and Bacteriology.

1. *Crown-gall.*

Inoculation experiments have been carried out on young trees of two apple stocks which have shown different degrees of susceptibility in the field, to ascertain whether the differences are observable under more controlled conditions. The trees will be examined during the winter of 1929–30.

An examination has been made of young apple trees (of two different stocks) which had been grown for two years on plots receiving different manurial treatment. No significant difference in the number and size of the galls on trees from the various plots could be detected.

2. *Brown Rot Diseases.*

Inoculations on pear flowers have been continued using a strain of *Sclerotinia cinerea* obtained from cherry. Positive results were obtained. These experiments together with those carried out in 1928 afford conclusive proof that *Sclerotinia cinerea* forma *pruni*, as found on plums and cherries, can cause a Blossom Wilt of Fertility pear trees.

Inoculation experiments have been carried out to ascertain whether strains of *S. cinerea* from plum, sweet cherry and Morello cherry respectively, can each infect the other hosts. The results obtained in 1929 show that *S. cinerea* from plum and sweet cherry is able to infect the flowers of the Morello cherry.

3. *Effect of Rootstock on the Susceptibility of the Scion.*

Further observations taken on the trial plot of Cox's Orange Pippin apples continue to confirm those of previous years, that the rootstock influences to some extent the susceptibility of the scion variety to Apple Scab and Apple Mildew. There is lack of conformity in the results for some stocks in different years, but the following data are more consistently obtained :—Cox's Orange Pippin is more susceptible (*a*) to scab on the twigs when worked on Malling No. I, IX, IV, XVI respectively than on XV, XIII and III respectively, (*b*) to scab on the leaves when on I, V, IX, than on XV, XIII, IV, (*c*) to scab on the fruit when on IX, I, than on XIII. The same variety is more susceptible to mildew on the twigs when worked on I, II and X respectively than on XV, IV, XVI respectively.

4. *The Pathology of the Raspberry.*

(1) *Blue Stripe Wilt.*—Previous observations and experiments have indicated that the intensity of attack of this disease on the canes of an infected stool is probably influenced to a large degree by external conditions such as temperature, humidity, etc.

This year, therefore, an experiment was carried out to determine whether the degree of parasitism of the causal organism artificially introduced into healthy plants could be modified by placing the plants under different conditions of temperature and humidity.

The results obtained indicate that the degree of parasitism can be modified by changing the environment, but further work is necessary to determine the influence of specific factors.

(2) *The Control of Cane Spot of Raspberry* (Anthracnose) *by spraying.*—The full results of the spraying trial against this disease carried out in 1928 are now available and indicate that although,

as mentioned in the previous report, the use of Lime Sulphur gave a better control of the spot lesions than Bordeaux Mixture, the effect of the Lime Sulphur on the canes was such as to cause a considerable reduction of the crop of 1928 and 1929 and a reduction in vigour of the new cane of 1928. It is hoped to plan a confirmatory trial using these two sprays, when sufficient mosaic-free cane is available. Meanwhile as Bordeaux Mixture has consistently given a good control of the disease without a trace of injury to the cane, this spray is recommended in preference to Lime Sulphur.

(3) *Raspberry Cane Blight.*—A serious outbreak of a disease (hitherto not recorded in this country) in a plantation of *Bath's Perfection* was investigated early in the season.

A fungus associated with lesions on the affected cane was isolated and has been proved by artificial inoculation to be the cause of the disease. The fungus answers closely to descriptions of *Coniothyrium fuckelii* the cause, in America, of a disease known as *Cane Blight.*

Subsequently, specimens of canes of other varieties of raspberry with similar symptoms were received.

Associated with the infected canes in many cases was the Cane Midge (*Thomasiniana theobaldi*). The lesions on cases provisionally ascribed to this midge are very similar to those caused by the fungus. It is proposed, in collaboration with the Entomological Section, to carry out infection experiments to determine the part played by the fungus and by the midge in the production of the symptoms observed.

(4) *Other fungi associated with diseased Raspberry Canes.*—Inoculations with the following fungi have been carried out :—

Botrytis sp.
Cryptosporium minimum.
Microthyriella rubi.

The *Botrytis* sp. was associated with a very serious attack on *Lloyd George* canes in the Midlands in the summer of 1927. The inoculations have shown that this fungus is strongly parasitic on raspberry canes.

Cryptosporium minimum has been shown to be parasitic to a small degree.

The effect of *Microthyriella rubi* on the inoculated canes was negligible.

Raspberry Mosaic. (*a*) *Experiments in Artificial Transmission.*—Results of grafting experiments carried out in 1928 can be briefly summarised as follows :—

(1) The disease can be transmitted to healthy plants by a method of " bark grafting " which has great advantages compared with the method of cleft-grafting, although transmission by the latter method is much more rapid.

(2) Evidence is provided that there are two distinct forms of mosaic with distinct symptoms within the variety *Baumforth Seedling B.*

(3) There is evidence that when diseased shoots of certain highly susceptible varieties are grafted on to the moderately resistant variety *Baumforth Seedling B.* the apparent resistance breaks down.

(*b*) *Field Experiments.*—(i) As indicated in the previous report, a plot for raising mosaic free stock of certain commercial varieties was planted up in the autumn of 1927-28. Periodic infections of this plot have been carried out during 1928 and 1929 and stools with definite symptoms, or suspicious in the least degree, were removed and destroyed. During 1929 only a very small number of diseased stools were found and a stock of mosaic free canes of certain varieties is now available for experimental purposes. It is hoped to extend this plot as material becomes available.

(ii) The field experiment on the control of mosaic in the variety *Lloyd George* has been continued.

A survey of the plot was made twice during 1929 and has provided interesting information on the mode of spread of the disease and on the possibility of controlling the disease in a commercial plantation by systematic rogueing.

(iii) Further notes have been taken on the incidence of the disease on varieties in the Research Station collection. A considerable amount of data is now available on the relative susceptibility of a large and comprehensive range of varieties.

5. *Bacteriosis of Plum and Cherry Trees.*

Cultural and infection studies of the organisms causing bacterial diseases in plum and cherry trees have been continued.

The distribution of Bacterial Canker is being investigated by means of visits to districts where the disease occurs and by the examination of specimens received from various localities. A survey of certain districts in Kent and Worcestershire was made in 1929.

Inoculations with the bacterial canker organism of plum trees have been made monthly to ascertain when infection of the stem takes place. It has been found that infection of the stem occurs more readily in autumn and winter than in spring and summer.

Experiments have been continued to determine whether the leaf-spot phase of the disease can be controlled by spraying.

6. *Walnut Bacterial Blight.*

The results of further cultural tests applied to the bacterium causing leaf-spots and stem lesions of walnut at East Malling have shown that it is identical with *Pseudomonas juglandis*, the Bacterial Blight organism of California.

7. *Apple Spraying Field Trials.*

The spraying trials for the control of Apple Scab and Apple Mildew on Cox's Orange Pippin have been continued and a small preliminary trial of various sulphur dusts has been made. The main indications from the trials up to the present are as follows :—

Apple Scab on Twigs, Leaves and Fruit.—Three applications of Bordeaux Mixture, one just before and two after blossoming have given the best control of scab, though on this variety the spray is quite unsafe to use. Three similar applications of lime-sulphur have also given very good control and the spray is safe to use at a strength of 1-30 before and 1-100 after blossoming. The pre-blossoming application is very important and checks the disease considerably even when not followed by post-blossoming applications. The latter, without a pre-blossoming application have also given good control.

Two post-blossoming applications of lime-sulphur (1-150) and colloidal-sulphur respectively, have given slight control.

Apple Mildew on Twigs.—The disease has best been checked by three applications of lime-sulphur, one before and two after blossoming. Two applications alone after blossoming have also checked the disease, but indications of control by a pre-blossoming application only are slight. Bordeaux mixture, while checking the disease somewhat, has been much less efficient than lime-sulphur. Two post-blossoming applications of lime-sulphur (1-150) and colloidal-sulphur respectively, have proved of little value.

Spray Injury.—Observations continue to reveal the harmful nature of Bordeaux mixture on Cox's Orange Pippin, even when applied before blossoming only. The injury takes the form of severe fruit russetting and moderate leaf scorching. The use of hydrated lime in a Bordeaux mixture of formula 8-12-100 has considerably accentuated this injury in 1929. Lime-sulphur used at the strengths given above appears to be quite safe to use. Spraying experiments on the variety Stirling Castle were discontinued in 1929 owing to the excessive injury caused in previous years by the sulphur preparations used.

8. *Blister Disease of Apples.*

Further examination of russetted apples and blistered twigs in 1929 has again revealed the widespread distribution of a fungus morphologically identical with *Coniothecium chomatosporum* Corda, the organism in all cases being closely associated with the above symptoms. Further work will be done in an endeavour to ascertain whether the fungus is responsible for the injury, and measures of control will be investigated.

V. ENTOMOLOGY.

Spraying Trials against the Fruit Tree Red Spider. Dormant Winter Washes.—Investigations in relation to the control of the

Fruit Tree Red Spider have been continued in the laboratory. The results obtained confirm those of 1927. The lubricating engine oil of declared consistency, and containing two per cent. active oil, destroyed 50 per cent. of the viable eggs of red spider. The white oil emulsion sprays applied at one and four per cent. were not toxic to the eggs of this mite.

Spring and Summer Washes.—Experiments were undertaken with a view to control the Fruit Tree Red Spider which occurs on plums, during the growing season.

Three sprays were tested under field conditions.

It was found that certain lime-sulphur preparations, applied as post blossom sprays, destroyed a high percentage of the mites and a commercial control was obtained.

The white oil emulsion sprays, and Bordeaux Mixture, which was applied as a combined acaricide and fungicide, proved to be of no value as a means of controlling this pest.

The life-cycle of the Red Spider has been worked out, and a report has been published.

A number of natural enemies of the Red Spider have been observed. Details of these and their possible connection with tar-distillate washes have been published.

In co-operation with the Biochemical Section, preliminary investigations on the control of Red Spider have been undertaken in the laboratory. A study of the mode of action of sulphur in killing the mite has led to a notable increase in efficiency of sulphur when treated by a new method in the laboratory. The results are encouraging, but further tests will be necessary before the trials are conducted in the field.

It has been found possible to kill Red Spider on Leveller gooseberry, a sulphur shy plant, by the above sulphur treatment without causing any leaf drop.

Resistance of different Root-stocks to Insect attack.—This investigation has been mainly confined to a collection of layered apple stocks, raised from immune seedlings. It has been found that all these layered stocks have maintained the immunity of the parents, after continued infections, throughout the summer months.

Similarly, stocks raised from plants known to be resistant to the attack of apple aphis, exhibit the same degree of resistance as the original plants selected for this character five years ago.

Apple Sawfly.—Further details of the life-cycle of the Apple Sawfly have been obtained. It has been established that the larvae may burrow into the soil to a considerable depth. This appears to depend upon the soil formation. At East Malling many larvae have been found 30 inches below the surface.

Control of Black Currant Gall Mites.

Big-Bud on Black Currants.—Preliminary spraying trials have been carried out to determine whether it is possible to obtain a still

greater measure of control of big-bud by means of a post blossom non-scorching spray, in place of the lime-sulphur at present used.

Gall Mites on Red Currants.—Preliminary field trials have been undertaken to test the value of lime-sulphur as a means of control. While it has been established that lime-sulphur will destroy the mites, it has not as yet been possible to determine the ideal period for its application.

Systematic Study of Gall Mites.—The general systematic work on the group *Eriophyidae* is being continued, and two more new species from abroad have been described.

The species of Gall Mites which occur on cultivated nuts in this country have been worked out, and a report is ready for publication. The Common Nut Gall Mite (*Eriophyes avellanae* Nal.) has been causing considerable damage to nut bushes by destroying the female flowers. The habits of this mite have been studied with a view to its control. Certain species of Gall Mites that occur on plum trees have also been studied.

Plum Leaf Hoppers.—Certain aspects of the life-history of two species of plum leaf hoppers have been investigated and it has been found that these insects spend the winter in the egg state. The eggs are deposited in the stems and branches of the plum trees during the autumn. The leaf hoppers emerge in the spring. An account of these observations has been published.

Raspberry and Loganberry Beetle (*Byturus tomentosus* F.).—Further observations have been made on the life history of this pest and a spraying trial conducted on a plantation of loganberries. From this trial it was found that although the pest could be successfully controlled by means of lead arsenate spraying, berries from plants so treated contained a dangerous amount of arsenic. It has been concluded therefore that the use of lead arsenate must be ruled out. A Derris Root preparation, an alcoholic extract of Pyrethrum and a white oil emulsion (this emulsion was used as a contact wash against the eggs) have also been tried but so far without success. A progress report has been prepared.

Insect Transmission of Raspberry Mosaic.—Work on this subject has been continued as well as present facilities permit. The raspberry aphis *Amphorophora rubi* has been used in cage inoculations, and the body juices of *A. rubi, Lygus pabulinus, L. pratensis, Capsus ruber,* and certain leaf hoppers (previously fed on Mosaic tissues) have been used in scratch inoculations in collaboration with the Mycological Section, but the results will not be obvious for at least another season.

Other Raspberry Pests.—Further observations have been made on the Cane Midge (*Thomasinaina theobaldi* Barnes) and investigations are in progress jointly with the Mycological Section to determine the relations between the injury caused by this midge and by the fungal disease known as Cane Blight.

Capsidae.—A systematic study of this group has been continued with special reference to the species of economic importance such as *Calocoris fulvomaculatus*, the Shy Bug of Hops, *Lygus spinolae*, also on Hops, *L. pratensis* and *Plesiocoris rugicollis*.

It has been determined and confirmed that the Hop acts as a summer host to the Common Green Capsid *L. pabulinus*.

Alcoholic aqueous and oil extracts of Pyrethrum were tested and found to be toxic to the nymphs of *L. pabulinus*.

Observations have been made on the methods of egg-laying and several species have been found to lay their eggs in wooden posts such as fence posts and hop-poles.

VI. HOPS.

Cultural Trials.—An examination of the results of the manurial trials indicated that the effect of distance apart, due in this case to dead hills, was well worth investigation.

The seedling variety L 21 has been used to plant up a plot for studying the effect of the distance apart of the hills, and the number of bines per string on the field per acre.

Preliminary trials to study the effect of Hard, Light, and Normal pulling, time and degree of severity in cutting, and the effect of "stopping" the bines at different heights, have been carried out.

New Seedlings.—The twelve most outstanding of Professor Salmon's seedling varieties tested at Malling during the first 14 years, and now planted out in larger numbers with Commercial varieties as control, have had crop records taken for the first time, and the results are promising.

Certain of the seedling varieties still continue to prove richer in preservative qualities than any of the Commercial varieties tested, when analysed by the Ford and Tait method.

In the Mid-season Hops two new seedlings have been added to those that proved richer than any Commercial variety. Of the Late Varieties six exceeded the highest Commercial variety (Petham Golding). Three of these have not been previously analysed. Of the New Varieties not previously analysed two (411, C9a) proved of superior preservative value to the richest hops obtainable on the market in 1928.

Brewing trials with the most promising seedlings are being continued. Further batches of New Seedlings have been planted out and are undergoing their preliminary trials.

Incidence and Control of Downy Mildew.—There was a fairly severe attack of the "spike" form of the disease in the spring and early summer, though the attack was not so severe as in the previous year. No spikes occurred after June 6th compared with July 10th in 1928. There was a slight attack on the cones of some of the more susceptible varieties just before picking commenced, but the dry and sunny weather during picking checked the spread of the disease.

14. HORTICULTURAL RESEARCH STATION, CAMBRIDGE UNIVERSITY.

The season was unfavourable to the production of vegetable crops and experimental work depending for its success on well grown cultures has, to some extent, suffered in consequence. On the other hand the severe frosts provided a test of the winter hardiness of the various strains of Brussels sprouts under trial and the prolonged drought threw an interesting light on the behaviour of onion varieties under adverse conditions. On the whole the season afforded more valuable information than would have been available had conditions been normal.

The policy of working in conjunction with County Demonstration Stations has been extended and arrangements made to co-operate with the Kirton Agricultural Institute in its celery trials and with the Cornish Demonstration Station in trials of broccoli. The trials of lettuces and cabbages carried out by the Middlesex County Council at Dehham have already provided both useful information and material for breeding experiments with these crops.

The year's work was carried out on the lines described in previous reports and trials of commercial stocks of various vegetables have again been fitted in with genetic investigations.

Onions.—Further useful information regarding the inheritance of a number of characters has been obtained but owing to the small quantity of seed produced under controlled conditions it cannot yet be considered to be statistically reliable. No progress could be made with the investigations on the inheritance of mildew-susceptibility owing to the non-occurrence of the disease during the season. The economic have outpaced the scientific results and a number of new varieties now await trial and comparisons with commercial stocks under varying conditions of soil and climate.

Brussels Sprouts.—The experience of growers catering for the late market and observations in previous years had indicated that there was a wide variation in the ability of plants of Brussels sprouts to resist frost. The experiences of the winter of 1928-1929 left no doubt on this point and the opportunity was taken of selecting frost-proof plants with high quality sprouts from the cultures of new hybrids which were under trial. These trials, made primarily for comparison with existing commerce stocks, showed in a convincing manner the possibility of improving the crop.

A culture which may prove of value for further breeding work of a self-fertile form, isolated a year previously was raised.

Broccoli.—Work in connection with the improvement of existing stocks of Roscoff broccoli was commenced and a trial of ten stocks undertaken.

Cauliflower.—Stocks of seed from self-pollinated plants selected for qualities of economic importance were obtained. So far all of the plants tested have proved self-fertile but as an offset to this useful

characteristic it has been found that the yield of seed from plants with a particularly good curd is comparatively small. The investigation on the inheritance of early maturity, now at the F_3 stage, was continued with interesting results.

Peas.—No variety trials were carried out but large F_2 cultures were raised from the crosses made in 1927. A number of fresh crosses to trace the mode of inheritance of size of seed, early maturity and double-podded-ness were made.

Parsnips.—Further material was raised for carrying on the work interrupted by the bad season of 1927. This consisted mainly of cultures from self-pollinated plants.

Cabbages.—Seed stocks of spring cabbages bred at the Station were obtained for comparative trials in the coming year.

Strawberries.—A small trial of the best of the American varieties previously tested and a few continental sorts provided further guidance for the breeding experiments.

Fruit.—Amongst the seedlings which fruited at the Station was a damson of sufficient promise to justify propagation during 1930.

Spraying.—The colloidal investigation of spray fluids has been continued, special attention being paid to emulsification and the formation of the correct oil-in-water type of emulsion during spraying. A study of the character and emulsifying properties of clays has been commenced.

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15. EXPERIMENTAL AND RESEARCH STATION, CHESHUNT.

The activities of this Station are concerned solely with glasshouse problems, and, during the course of the year, all phases of the industry have been dealt with.

(1) Manurial and crop management trials with the tomato have been continued and the following facts are indicated :—

(*a*) The experiments to test the effect of different amounts of stable manure per acre have been continued since 1926, and, as in previous years, 15 tons per acre have proved as effective as larger amounts.

(*b*) The substitution for stable manure of wheat straw or bean straw has been continued and it would appear that this substitution can be made at intervals without affecting the crop. The application of wheat straw in addition to stable manure seems justifiable, but some reduction in yield occurred when stable manure and bean straw were applied together.

(*c*) An increase in crop was obtained by treating the soil with formaldehyde and taking a crop of tulips prior to tomatoes. The

increase was only slight where this treatment had been applied also in 1928.

(*d*) The experiments in which lime was withheld from soil deficient in carbonates were repeated. As in 1928, the plots without lime produced a heavier crop than the limed plots.

(*e*) During 1928 applications of a top dressing fertilizer at the rate of 2 ozs. per sq. yd., were compared with those of 1 oz., the result being in favour of the heavier dressing. The experiment was repeated during the present season, and no difference in crop was obtained. The investigation will be repeated.

(*f*) The watering experiments of 1928 were repeated with slight variation. Two plots were watered with a hose in the usual way, two were watered through underground pipes, while in two the plants were set out in shallow trenches which served to collect the water round the immediate vicinity of the plant. Two plots were hoed regularly through the season.

The results were in favour of planting in trenches and watering by buried pipes. In the latter case, however, it was necessary to cease the application of water from below after the beginning of June, because the lower region of the soil became water-logged and some yellowing appeared on the foliage. The bottom crop was excellent, and there are indications that subterranean watering is of considerable importance at the beginning of the season.

(*g*) In 1928 crosses were prepared between the tomatoes Stirling Castle and E.S. 1, and Up-to-date and E.S. 1, Stirling Castle and Up-to-date being highly resistant to *Cladosporium fulvum*. The F_2 generation were tested in tomato house 1. Unfortunately, mildew was not sufficiently serious to provide a reliable test of resistance, and, further, the quality of the fruit produced by the plants was poor. Further crosses with other varieties have been prepared and the progeny will be examined in 1930.

(*h*) The investigations of the temperature requirements of the tomato commenced in 1928 were continued. The evidence obtained in 1928 indicated that with E.S. 1 a night temperature between 63° and 65° F. was necessary for the best results. During the present season, using the variety Craigwood, similar weights were obtained at minimum night temperatures of 60° F. and 65° F.

(*i*) The process of heating soils by resistance wires heated by electricity has been further examined, but unfortunately only one coil survived until the end of May; the others on examination proved to be corroded. The only plot heated by this method was held at a temperature of 82° F. during April to May; and a crop of 59 tons per acre was obtained representing an increase of 10 tons per acre over the control. The question of soil temperature is most important for nurserymen, and every effort will be made to devise some cheap method of warming the borders.

(*j*) A general survey of the temperature conditions prevailing in glasshouses was begun during the current year. Comprehensive records were taken of soil and air temperatures in different parts of two tomato houses ; one the old vinery type, and the other the newer " aeroplane " type with high gutters.

(2) *Cucumber Experiments.*—(*a*) The cucumber experiments were designed to test the effect of opening the beds by the addition of various spongy materials.

The addition of peat moss, even in the presence of lime, proved harmful. In previous years the crop has been improved by incorporating straw and bean straw with the beds, but during the present season they were without effect.

(*b*) Sterilisation of the base by steam again increased the crop considerably, the greatest increase occurring in plots 4–6, house G, where last year's beds were dug into the base prior to steaming.

(*c*) Cucumbers were again grown in a house, the glass in the south half of which transmits part of the ultra violet rays of the sun, and that in the other half of which is ordinary glass. The crop was only 5 per cent. greater under the ultra violet light glass than under the ordinary glass. Last year an increase of 25 per cent. was recorded.

(3) *Animal Pests of Glasshouses.*—(*a*) Red Spider Mite (*Tetranychus telarius* L.).

The Red Spider investigations have been continued. The value of naphthalene fumigation in the autumn and the early and systematic spraying of the plants with petroleum emulsions throughout the season has been confirmed on commercial nurseries.

(*b*) White-Fly Parasite (*Encarsia formosa* Gahan).

The Chalcid parasite, *Encarsia formosa*, is becoming a popular means of controlling White fly in glasshouses. Its distribution has been continued through the season. Considerably over a million parasites have been distributed from the Station, and applications were so numerous that it was impossible to supply all the material required.

It is anticipated that the demands will increase to such an extent that the present accommodation for breeding the parasite will prove hopelessly inadequate.

(4) *Diseases of Glasshouse Plants.*—(*a*) *Tomato Leaf Mould or Mildew.*—The relation of leaf mould (*Cladosporium fulvum*) to environmental conditions was studied on commercial nurseries during the past season ; temperature and humidity records were taken by thermohygrographs, and notes were made concerning the appearance and development of leaf mould, ventilation, watering, etc. Omitting the sunny periods, 20–26 May, 1929 and 8–24 July, 1929, the weekly average temperature was well below the optimum for leaf mould (72° F.) till the end of August. The weekly average humidity was usually 75–85 per cent. ; the weekly average maximum humidity

was 90–95 per cent. ; and on dull or rainy days the humidity was 80–90 per cent.

Night ventilation varied considerably in different nurseries ; in many cases little was given till July, and the ventilators were closed throughout the entire season.

Leaf mould was far less severe than in other years. As a rule soft, forced plants which developed quickly suffered most.

Experiments have suggested that the mode of infection is not exclusively stomatal, and that the fungus may cause considerable reduction in yield by attacking the flower trusses.

The spores of *C. fulvum* have been found to overwinter in glasshouse structures and in the soil. It has been shown also that the spores of this fungus may be destroyed by burning sulphur in the house or spraying with emulsified cresylic acid. This suggests that glasshouses may be freed from infection by such methods. The investigations are being continued.

(*b*) *The Microflora of Glasshouse Soils.*—An examination is being made of the microflora of the soil of a house devoted to manurial experiments. Bacterial counts throughout the season suggest that variations in the manurial treatment are not reflected in the numbers of bacteria present at a given time, with the exception of plots receiving no manure and stable manure respectively, the latter showing a temporary large increase in the early part of the season. A point of importance is the sudden fall in the numbers following the first heavy watering, suggesting the carrying down of the bacteria to lower levels of the soil. In the early part of the season the numbers of actino-mycetes varied inversely with those of the bacteria, but later followed them more closely. Fungi were relatively scarce, the highest number being recorded in plots receiving stable manure and artificials without nitrogen. The highest numbers were recorded in May.

(*c*) *" Damping-off " of the Cucumber.*—Attention has also been paid to fungi causing " Damping-off " of tomatoes and cucumbers. Three species of *Phytophthora* are concerned, one of which was formerly thought to attack the cucumber only. It has now been found to attack the tomato, especially in the young stages.

P. parasitica and *P. cryptogea* which commonly attack the tomato have been found to infect cucumber seedlings in the early stages.

(*d*) *Mosaic Disease.*—It has been shown conclusively that Mosaic disease of both tomatoes and cucumbers is frequently carried by the seed. Stocks of clean seed have been obtained by systematic roguing of infected plants. Clean crops resulted when this seed was used and simple precautions taken to prevent reinfection.

(*e*) *Disinfection of Tomato Seeds.*—The effect of treating tomato seeds with the common seed disinfectants and of exposing them to wet and dry heat has been investigated. It has been found that they will stand relatively high temperatures after systematic pre-heating.

(*f*) *Chemical Investigations.*—(i) Last year it was reported that considerable damage to tomato plants had been traced to the presence of chlorates in the soil. In an attempt to account for these compounds all the artificial fertilisers ordinarily used have been examined for chlorates. None of the samples examined contained chlorates.

(ii) Several soils submitted for analysis and containing granules of calcium carbonate have been found to give a positive acid reaction in Comber's test. The attention of growers has been drawn to the desirability of ensuring thorough mixing of lime with the soil.

(iii) Steaming has been shown to minimise the effects of manurial deficiencies on the tomato crop, and analyses made this year show that this is accompanied by some degree of uniformity in the composition of the foliage of plants growing in the different plots.

D.

ENTOMOLOGY
and
PLANT PATHOLOGY.

16. PLANT PATHOLOGICAL LABORATORY, MINISTRY OF AGRICULTURE AND FISHERIES.

The functions of this laboratory are described on page 50 of the Imperial Agricultural Research Conference volume entitled "Facilities for Advanced Study and Research in Agricultural Science and the Cognate Pure Sciences in the United Kingdom," and it is sufficient here to point out that the Laboratory is not primarily a research institution. Investigations are carried out only in so far as other duties permit: such investigations are usually of a co-operative nature, planned and carried out jointly with members of the Advisory and Research Services, and reference to the same experiment may, therefore, occur in the accounts of work at several different stations. For a similar reason no account is given in this section of certain projects in which the Plant Pathological Laboratory is interested since they will be fully dealt with by the other Stations concerned.

Pyrethrum Investigation.—A general investigation into the cultivation, the chemical properties, and the uses of the flowers of *Chrysanthemum cinerariaefolium* (Dalmatian Pryethrum) is in progress. The share of the Ministry's Laboratory chiefly concerns the cultivation of pyrethrum with special reference to its production in England and Wales or elsewhere in the Empire, and to the development if possible of a strain of the plant giving flowers with a high content of pyrethrins. The investigation has shown that pyrethrum is able to flourish under different conditions in many parts of England, and the work is now concerned with the growing of areas of a sufficient size to enable the commercial possibilities of the crop to be tested.

Potato Eelworm Investigation.—In parts of England and Wales, certain fields or areas have become "potato sick" and no longer produce profitable crops of potatoes. The trouble is customarily associated with an eelworm (*Heterodera schachtii*) but this organism has never been proved to be the causal agent. An investigation is in progress to discover (*a*) the real cause of the trouble, (*b*) any methods of dealing with potato-sick land. Work during the past season has failed to give evidence that the eelworm is seriously harmful. For instance, potatoes grown in sterilised "potato-sick" soil to which eelworms have been added have developed healthily in spite of a very heavy infestation of eelworms on their roots, whereas potatoes in the same soil unsterilised but containing the same number of eelworms as the sterilised soil have shown a typically diseased condition. Again, careful sampling of the soil in three of the chief areas affected has so far failed to show any definite correlation between the number of eelworm cysts present in the soil and the condition of the crops. On the other hand, no other pest or disease has yet been discovered which is likely to prove responsible for the trouble (but see later "Potato Sickness").

As regards treatment of affected soil, three centres (Manchester, Leeds, and Kirton) have co-operated with the Laboratory in testing applications of naphthalene and bleaching powder, the former having already given some results prior to the present season. During 1929 the potato-sick condition did not develop to such a marked extent as in 1928, and so far as the returns have been examined, one suggests a gain in the case of the naphthalene treated plots, and the two others no significant difference between treated and untreated plots.

Strawberry Moth Investigation.—This investigation is concerned with certain tortricid moths of the genus *Acalla* which attack strawberry, azalea, willow, and other plants, and owing to the uncertainty in regard to specific and racial limits within the genus, or species of the genus, the work has developed as a fundamental study. The mode of inheritance of the different forms has been studied, and has been shown to follow Mendelian lines. It has been proved that the so-called *A. comparana*, harmful to Azaleas under glass, is really the strawberry species *A. comariana*, the individuals from Azalea having a preference for strawberry, even after two or more generations upon the former plant.

Woolly Aphis Parasite.—In 1923 a stock of the Woolly Aphis parasite, *Aphelinus mali*, was obtained from France, and has since then been bred in insectaries at the laboratory. Attempts have been made each year to establish the parasite in the open in various parts of the country, but little success has been achieved. In the present year, however, parasites introduced into a very heavily infested orchard at Chislehurst, Kent, have increased to a very great extent and have spread to a considerable distance through the orchard, and it is hoped that in this case they may become definitely established.

Co-operative Bunt Trials.—During 1926–1928 the majority of the Advisory Mycologists co-operated with the Laboratory in carrying out field trials with the object of comparing the fungicidal value of copper carbonate powder with that of copper sulphate and formaldehyde solutions in the control of Bunt in wheat. In the period under review all the data obtained from these trials have been carefully examined and tabulated at the laboratory and an article embodying the results and conclusions to be drawn from the trials has been prepared with a view to publication in the Ministry's Journal.

Bulb Diseases.—Further progress has been made with the collection and examination of all the available literature on the various diseases of the commoner bulb- and corm-forming flowering plants, and this study is now nearing completion. Investigational work of a preliminary nature carried on simultaneously with the above, has revealed the existence of two entirely new diseases. A rot of lily bulbs grown in Japan was shown to be due to *Sclerotium*

Rolfsii, a fungus not hitherto found on this host, and a wilting and rotting of Gladiolus plants, closely resembling " Shanking " in tulips, was found to be associated with *Phytophthora Cactorum*. In addition, Scab and Neck Rot of Gladiolus, caused by *Bacterium marginatum*, were observed for the first time in this country.

Potato Blight.—In collaboration with the provincial advisers, a set of experiments was set up to test the hypothesis that the incidence of Blight on potatoes varied according to the age of the plant at the time of infection. Owing to the dry season, no Blight appeared in the plots at the Pathological Laboratory, or at several of the other centres. At the centres where Blight did appear, it occurred too late in the season to exhibit differentiation in attack.

Potato Sickness.—Experiments were arranged to test the idea that the fungus *Corticium Solani* (*Rhizoctonia Solani*) might cause this trouble. Active cultures of *Corticium Solani* were added to pots of sterilised soil, but though abundant fructifications were produced at the collars of the plants, and the fungus was abundant on the underground parts of them, they did not show " sickness." Plants likewise remained healthy when grown in soil to which had been added both *Corticium* and eelworm. In sterilised soil the plants maintained their vigour, but in unsterilised they showed the typical appearance of the disease.

Other Experiments.—Feeding barley from the U.S.A., imported into England during the autumn of 1928, gave rise in many cases to sickness in pigs when fed to them. It was discovered at the Pathological Laboratory that such toxic barley was affected with the disease known in the U.S.A. as " Scab " and that the fungus *Gibberella Saubinetii* was present on it in considerable amount in its perithecial condition. Experiments on the question of the toxicity of this fungus to pigs were started in co-operation with the Veterinary Laboratory at Weybridge, and are still in progress.

A considerable amount of culture work was carried on in connexion with the parasitic fungus that causes Canker and Dry Rot of swedes. It was proved that certain fungi which occur on swede seed raised in England and which had been claimed to be strains of the parasite of Canker and Dry Rot (*Phoma Lingam*) were nothing of the kind, and were non-pathogenic. In conjunction with the Advisory Centre at Reading, it has been found that *Phoma Lingam* does occasionally occur on swede seed, but to a less extent than has been maintained in some quarters. It has further been confirmed that the two diseases are sometimes seed-borne, but in this country, at any rate, the evidence obtained shows that they are much more frequently contracted from the soil or from a neighbouring diseased crop.

17. POTATO VIRUS RESEARCH STATION, CAMBRIDGE UNIVERSITY.

Isolation of Virus-free Stocks.—Besides the varieties Abundance, Arran Chief, Arran Comrade, Arran Victory, Epicure, Great Scot and President, which are believed to be free of disease, and of which considerable stocks are now in hand, the Station has small stocks of Arran Crest, Champion, Di Vernon, Duke of York, Eclipse, Kerr's Pink, and Majestic, which the Station has reason to believe are also virus free. All stocks of King Edward, however healthy in appearance, are found to be infected with Para-Crinkle. Several trials on a small scale of the Station's stocks versus best Scotch have been made: they have all shown the very striking superiority of the virus free stocks although they are in the fourth year south. Virus free stocks have been found to mature one to two weeks later than commercial stocks, and to be less affected by ordinary blight. Yield trials on a big scale will be made in 1930.

Research into the Crinkle group of diseases has been continued with success: the relation and reaction of Crinkle " A " and Para-Crinkle have been fully investigated. One form at least of Curly Dwarf has been definitely shown to be only an effect of environment on plants infected with Para-Crinkle.

Further use of the Datura plant as a guide in diagnosis has been made.

Mr. F. M. Cory, late assistant to the Director, grafted *S. nigrum* to healthy potatoes and found that the weed was capable of conveying Crinkle. This observation is being followed up.

The researches on *Phytophthora* resistance were held up owing to the fact that no infection of seedlings could be obtained artificially or otherwise.

Further work has been done on Colour Mutation and some progress made with the genetics of wild species of tuber-bearing Solanums.

Report of the Entomologist.—Research has been carried on with the following potato virus diseases—crinkle, interveinal mosaic and leaf-roll, and their relationships with insect vectors.

Crinkle.—In the course of studies upon the virus of a potato crinkle, the following facts of importance have been determined.

(1) The aphis *Myzus persicæ* will transmit this virus from diseased to healthy potatoes; so far successful transmission to one variety only has been obtained.

(2) *M. persicæ* will transmit the crinkle virus to tobacco, where it shows very faint symptoms; the aphis will pick up the virus again from such infected tobacco and infect healthy potato. The infective power of the virus seems to be increased by this process, and the aphis is enabled to infect potato varieties which it had failed to infect before passage of the virus through tobacco.

(3) Needle and aphis transmission of the crinkle virus to tobacco produces diseases in which the symptoms are characteristic of the method of infection.

(4) Passage of the crinkle virus by needle through tobacco increases its virulence both to tobacco and potato.

(5) Evidence has been obtained that symptoms in a plant host may vary according to the method of infection of that plant host.

(6) In conjunction with Mr. Cory, the Solanaceous weed *Solanum nigrum* has been found to " carry " certain potato viruses, and so to act as reservoirs of infection in nature. Healthy potato plants have been infected with crinkle and streak with great regularity by means of the aphis *M. persicæ* from such solanaceous weeds.

Interveinal Mosaic.—(1) This virus has been transmitted to healthy potatoes by means of *M. persicæ ;* one variety only so far has been thus infected.

(2) Passage of this virus through tobacco alters its nature and develops the more lethal streak element.

Leaf-Roll.—Further experiments with this virus and its carrier *M. persicæ* have shown—

(1) That two hours feeding upon a healthy potato plant by an infective aphis are sufficient to infect that plant.

(2) That the uninfective aphis becomes infective after six hours feeding upon a leaf-rolled plant.

(3) That a total period of about 54 hours is necessary for an uninfective aphis to pick up the leaf-roll virus and infect a healthy potato plant.

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18. SILVER-LEAF DISEASE INVESTIGATIONS, CAMBRIDGE UNIVERSITY.

During 1928-9 work has been chiefly concentrated on the elucidation of the occurrence of Silver-leaf disease in young nursery trees and stocks. The causative fungus, *Stereum purpureum,* is very rarely present in the tissues of silvered suckers arising from diseased trees, which are said to be used sometimes as stocks. Generally speaking, silvered suckers when detached from the parent tree and planted separately produce healthy foliage in the following season. In the practice of budding plum stocks there is great danger of infection by *Stereum purpureum* when the stocks are cut back unless the exposed extremities are covered with some protective substance ; most of the silvered nursery trees examined have become infected in this way.

Plum trees which have recovered from the disease have been cut up in order to ascertain whether the fungus had become inactive in the tissues or whether it was actually dead. In these trees the fungus had invaded the tissues extensively but its progress laterally had been checked by the formation of "gum-barriers." Evidence was obtained that in these trees the fungus was dead and not merely inactive.

It has been ascertained that a marked correlation exists between recovery from the disease and increase in vigour of the tree.

Among the progeny of selfed Victoria plums at the John Innes Horticultural Institution two types have been shown to exhibit considerable resistance to *Stereum purpureum*.

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19. BIOLOGICAL FIELD STATION, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

This station was established in 1928 for the investigation of the problems arising from the infestation of stored products by insects and moulds. The station was occupied in June, 1929, and at present the research in progress is concentrated on the study of the problems presented by the occurrence of insects and moulds in dried fruit, cacao and copra.

The work is divided into two sections ; (*a*) survey and intelligence work, conducted from the Imperial College of Science and Technology in South Kensington, and (*b*) biological and chemical work conducted at Slough.

The progress made in the survey work consists of a survey of the insect infestation of stored cacao, a report on which is now in the course of publication by the Empire Marketing Board, and a survey of the problems arising from the infestation of cacao and copra by moulds. As regards dried fruit, a study of a series of experimental consignments of dried fruit from Australia has been made.

With regard to biological work, this has consisted in a systematic study of all insects occurring in cacao, spices and dried fruit and detailed biological studies of the moths *Plodia interpunctella*, Hb., *Ephestia elutella*, Hb. and *Ephestia cautella*, Wlk.

On the chemical side of the work, a study of the chemical and entomological aspects of mixed fumigants is in progress.

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20. PLANT PATHOLOGICAL LABORATORY, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

Work on Plant Pathology with a special reference to Horticulture was instituted at the University Department of Botany, Royal Botanic Garden, Edinburgh, in 1924.

Work on Plant Diseases falls naturally into two divisions :—

1. *Advisory Work.*—Advisory work is carried on by the Department's Laboratory in conjunction with the three Agricultural Colleges. All common and well-known diseases are dealt with by the skilled horticulturists on the staff of these Colleges. In cases of difficulty they ask the co-operation of the Laboratory. Between 700 and 800 questions were dealt with by letter, and, in addition, by visits where necessary, during the past year. All the more frequent questions unless dealt with by leaflet are made the subject of short typed memoranda frequently brought up to date. Every use is made of the Ministry of Agriculture's leaflets. A good deal of travelling is done, as frequently problems can only be elucidated on the spot. The work is almost entirely horticultural. The facilities are used by market gardeners and fruit growers, glass-house men and some private gardeners. The growers round Edinburgh come in for help and consultation to the Laboratory, where a set of dried specimens of diseases and a collection of spirit material are available for comparison. Visitors from elsewhere are also received, especially from England, but also this year from America, Czecho Slovakia, Korea, Holland, New Zealand and Sweden.

2. *Research.*—Several projects are in hand. Work is proceeding on the fungus which is considered the cause of the strawberry disease in Lanarkshire, a phytophthora of a rather unusual type. Further experiments on the seed infection of Clover are in hand in conjunction with the Seed Testing Station. A general study of the Phytophthoras is being made by Mr. C. E. Foister. This is a group that is being recognised each year as more important to all horticultural crops and some member of which causes severe disease to potatoes, tomatoes, onions and leeks, fruit-trees, strawberries and many ornamental plants.

Atropa belladonna.—The disease of this plant has been further investigated during 1929 and proof established as to the pathogenicity of the species of Phytophthora isolated from diseased plants. The occurrence of the disease has been restricted this year owing to weather conditions and it was not, therefore, possible to test control measures in the open field. Work aiming at establishing the above fungus either as a strain of *Phytophthora erythroseptica* or as a " new species" has been carried out and it is expected shortly to publish notes on these researches.

Leek.—A peculiar " stripe " disease found on Leeks in previous years has not been noticed this year, and therefore field tests of its infectiveness have been prevented. It was previously suspected

as a Mosaic disease: one experiment last year seemed to confirm this supposition. It is therefore interesting to note that a very similar disease of a Mosaic nature has been reported on Onions in America.

Weather conditions have probably been responsible for the absence this year of a Phytophthora disease of Leeks reported in 1928. It is hoped that during 1930 this disease may be studied more and the causal fungus isolated.

Bracken Eradication Investigation.—This investigation is carried on by the Department's Plant Pathology Department in co-operation with Professor K. W. Braid of the West of Scotland College of Agriculture. Reports of disease on Bracken having been received from the West and South the study of the problem was undertaken in 1928. During the year 1929, and particularly in the winter months, work was carried out in the Laboratory.

Visits were paid to diseased or suspected areas in various parts of the country. In the South-west, Dumfries (Langholm), Kirkcudbright and Wigtown, Ayrshire and Lanarkshire were visited, the most striking areas being at Westwater, a very extensive area on the Duke of Buccleuch's estate, near Langholm, Bridge of Urr and Caigton, near Castle Douglas, and at Knoweside near Maybole. In the Border area, Peebles and Selkirk were visited, where Caddonhead near Galashiels proved the most interesting. In the Central region large areas of bracken were examined in Perthshire and Dumbartonshire, particularly Dunkeld, Aberfoyle, Callander, Monteith hills districts in the former and Garelochhead and Glenfruin in the latter. In the East, bracken areas in Angus, Fife and Kinross were examined. In the Western region, Jura, an interesting new area where the disease is very marked and in Argyllshire, Kilmelfort, Oban and Taynuilt were visited. Argyll as a whole appears to be largely affected.

The severity of the attack was found to be greatest in the West, Garelochhead being one of the most striking areas, and it is proposed to carry on intensive work in that area during 1930. An especial effort will be made to find some easy means of spreading the disease.

Experiments on infection were carried out at Loganlee, Boghall, Pentlands, Venlaw, Peebles, Dunearn and Pitreavie, Fife.

An experiment on chemical treatment was carried out at Loganlee, Pentlands, on the estate of Mr. A. Cowan, in co-operation with the Edinburgh and East of Scotland College of Agriculture. In furtherance of the work of the late Dr. W. G. Smith, dry crystalline Sodium Chlorate was applied at different rates per acre in late May to an area of vigorous bracken and the results were found to be very encouraging.

21. SEED TESTING AND PLANT DISEASES DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Seeds.

Further experimental shipments to America of parcels of Rye-grass seeds under control have been made in collaboration with the Washington Seed Laboratory. Evidence is that temperature alone does not account for loss of germination nor does moisture alone. The coincidence of the two is being investigated. A laboratory "voyage" under controlled conditions suggests that moist warmth for a sufficient period probably does occur.

Weeds.

Trials of sodium chlorate as a weed killer for arable land have been very successful. Used against rushes in pasture the chlorate has not succeeded unless applied in uneconomic quantities.

Seeds Mixtures.

Analyses have been made of hay from all mixture trials sown in 1928. Turf analyses from 1927 sowings are in hand. Timothy and Cocksfoot have contributed much more than was expected to the hay crops. Trefoil contributed nothing.

Wild White Clover.

A survey was made of comparison plots of English, Irish, and New Zealand stocks of Wild White Clover sown in several previous seasons. The English has succeeded best, the Irish nearly as well and the New Zealand very badly.

Potato Diseases.

Ordinary or Late Blight (*Phytophthora infestans* de Bary).—Attention has been given to the following problems :—

(1) The use of soda ash in place of washing soda in the preparation of Burgundy mixture. No spray injury was caused nor was the fungicide prepared with soda ash found to be inferior to that prepared with washing soda for the season 1929.

(2) The dissolving together of the copper sulphate and washing soda in the preparation of Burgundy mixture. Although there are certain technical drawbacks, such as the more rapid settling of the precipitate in this method of preparation, the results obtained during 1929 were equal to those given by the application of the mixture prepared in the orthodox manner and no spray injury was caused.

(3) Results obtained in 1929 from experiments dealing with the comparison of spraying and dusting are not of great value owing to the late appearance of ordinary blight during the season. The first record of the appearance of the disease in the experimental plots was made on August 22nd.

Pink Rot (*Phytophthora erythroseptica.* Pethy. and Murphy).—The study of this disease has received attention both in the laboratory and in the field. A study dealing with the physiology of the fungus is in progress and interesting observations have been made in connection with the method of overwintering and the environmental conditions favouring oospore production. Field observations have indicated that the disease is more prevalent than is generally supposed, the identity of the primary parasite often being obscured by the rapid invasion of the tuber by secondary organisms which, under field conditions, produce a "wet rot."

Flax Diseases.

Seedling Blight (*Colletotrichum linicolum* Pethy. and Lafferty Browning) (*Polyspora lini.* Lafferty). A good deal of work has been done in connection with the determination of the extent of the occurrence of these seed borne diseases in samples of flax seed, and preparations are being made for the carrying out of field trials for their control. A study of the physiology of *Colletotrichum linicolum* is in progress.

Oat Diseases.

Oat Smut (*Ustilago avenae* (*Pers.*) Jens. *and Ustilago* Kolleri, Wille).—Various methods of seed treatment for the control of these diseases in the field have been investigated in the field during 1929. Copper sulphate, formalin (steep and sprinkle), copper carbonate dust, sulphur dust, and organic mercury compounds (Bayer Products) have been used. Satisfactory control of smut has been obtained and an outstanding result has been that given by the use of organic mercury compounds. Seed treated with these produced a stronger braird; the superiority in growth of the crops in these plots was noted throughout the season. The establishment of a vigorous and healthy braird free from attack by fungi in general and more fitted to withstand adverse weather conditions is an important factor in oat cultivation in Northern Ireland.

Leaf Spot (*Helminthosporium avenae* (*Brit. and Lav.*) Eid.)—This fungus has been isolated from diseased oat leaves and if time permits it is proposed to investigate the nature of the damage it may cause to the oat crop and the best method for obtaining its control.

Fruit Diseases.

American Gooseberry Mildew (*Sphaerotheca mors-uvae* (*Schw.*) *Berk*).—Further experiments have been carried out dealing with the control of this disease. Ammonium polysulphide still remains the most effective spray fluid for use with those varieties of gooseberries which are not subject to polysulphide spray injury. For those varieties susceptible to this form of spray injury, washing soda remains as the most efficient substitute. Dusting with finely ground sulphur has again given excellent results.

Apple Scab (*Venturia inaequalis*, Aderh.).—The campaign dealing with the summer spraying of apple trees for the control of apple scab is making good headway in the fruit-growing areas of Northern Ireland, particularly in County Armagh, and it is expected that in the course of a few seasons summer spraying in this connection will be considered as part of the routine connected with the cultivation of the crop. The first part of a paper dealing with the results obtained has been published and the second part will be ready for publication shortly. Bordeaux mixture still proves to be the most satisfactory fungicide for controlling scab in Northern Ireland. Experimental work is still in progress with a view to determining the most satisfactory strength of Bordeaux mixture for general use; to elucidating problems connected with the use of an excess lime mixture; and to the investigation of general problems dealing with the occurrence and control of apple scab.

Spring Frosts.—The study of the occurrence of late spring frosts causing damage to apple blossom is still in progress.

Winter Spraying.—Co-operation with the Chemistry Department of the Queen's University has been established in connection with the study of the chemistry of tar oil winter washes, and with a view to the possibility of their manufacture locally. So far, very satisfactory results have been obtained with various washes which have been tested during 1929.

Forest Tree Diseases.

Seedling Diseases.—An account of the work dealing with the control of seedling diseases and weeds in the forest nursery has been completed and is ready for publication.

E.

AGRICULTURAL PARASITOLOGY.

22. INSTITUTE OF AGRICULTURAL PARASITOLOGY, LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE.

In connection with the establishment of field-plots devoted to plant diseases due to parasitic nematodes, to which reference was made last year, particular mention may be made of the observations of Dr. Goodey on the *Anguillulina* (*Tylenchus*) *dipsaci* plot on which potatoes are grown. During 1928 a varieties trial was carried out, and ten different varieties of earlies, second-earlies and maincrops were grown, with the result that all were found to be susceptible to attack.

In the laboratory, Dr. Goodey continued his studies on the genus *Aphelenchus*, some species of which are plant parasites, whilst others, closely similar in appearance, are free-living in soil, on grass and in decaying organic matter. A detailed study has also been made of a worm, *Anguillulina musicola* Cobb, 1919, parasitic in diseased banana roots which came from the Royal Botanic Gardens, Kew.

Observations have been made on *Anguillulina dipsaci* attacking potatoes and mangolds. A host-list of plants attacked by this parasite has been published in the Journal of Helminthology. A number of new genera and species of free-living nematodes has been discovered at Winches Farm.

Miss M. J. Triffitt has continued the investigations on means of control of *Heterodera schachtii* on potatoes.

Field observations have been made at Ormskirk on land heavily infected with a strain of *H. schachtii* specialised on potatoes, and also in the neighbourhood of Bristol, where a strain attacking mangolds was reported to the Institute. The viability of the parasite after passage through the pig has been tested in connection with some field observations carried out at Ormskirk.

Further laboratory studies on the factors influencing the hatching-out of larvæ from the brown-cyst, with special reference to the effects of the excretions of mustard and potato roots, have been carried out.

Various protozoan infections which have been discovered by members of the Institute have been investigated.

Dr. D. O. Morgan has continued his detailed enquiry into the morphology and biology of the infective larval stage of some of the commoner parasites of sheep. Special attention has been devoted to the third stage larva of a stomach worm of sheep and goats, viz., *Ostertagia circumcincta*. He has also made a close study of the common sheep lungworm, *Muellerius capillaris*.

An examination of helminthic parasites from wild animals at the Farm has been continued, and has resulted in the discovery of two species of nematodes new to science.

Dr. J. N. Oldham has continued the investigation and survey of the insect fauna of pastures in an attempt to discover the vector and elucidate the life-history of *Moniezia*, the common parasitic tapeworm of lambs. Collections of dung-frequenting insects have been carried out, and a large number of dissections performed. Additions to the named type collection of coprophagous insects have also been made.

Biological studies on the eggs of the sheep tapeworm are being pursued with a view to discovering conditions or stimulants in producing or aiding hatching.

The cestodes of rodents have also occupied attention, and detailed studies of the anatomy and morphology of some species are in progress.

Miss P. A. Clapham has been employed in collaboration with Mr. J. J. C. Buckley in an examination of the activities of fungi in destroying the eggs of helminths.

During the past year over 100 kids have been collected from members of the Goat Society in various parts of England. These have been hand reared with a view to later use for chemotherapy experiments.

F.

ANIMAL PATHOLOGY.

23. RESEARCH INSTITUTE IN ANIMAL PATHOLOGY, ROYAL VETERINARY COLLEGE, LONDON.

1. *Anaerobic Infections of Sheep.*—As intimated in previous reports, the principal disease under investigation has been that known in Kent under the name of " struck." Earlier work indicated that the chief organisms concerned etiologically were *B. chauveaui* and *vibrion septique*. During the spring of 1929 it has been possible to make a more extensive bacteriological survey with the result that a pathogenic anaerobe resembling *B. welchii* has been encountered in the lesions from a number of cases. This anaerobe though similar to *B. welchii* does not appear to be identical with it since experiments have shown that *B. welchii* antitoxin gives no protection against the toxin of the sheep anaerobe.

It has not been possible to carry out satisfactory vaccination experiments in the field during 1929, partly on account of the low incidence of the disease.

2. *Types of Tubercle Bacilli isolated from Cases of Tuberculosis in the Horse and other Animals.*—With the object of ascertaining the type of tubercle bacillus responsible, an examination was made of tuberculous material from horses, dogs, cats, a parrot and a wallaby.

From their dysgenic type of growth in culture media strains of tubercle bacilli from thirteen cases of tuberculosis in horses resembled the bovine type, though four of these were atypical in being distinctly below the standard virulence for laboratory animals. Of sixteen cases in dogs six were evidently of bovine origin and from the remainder tubercle bacilli of human type were isolated. Five cases of tuberculosis in cats appeared to be of bovine origin. The case of tuberculosis in the parrot was of human origin, while infection in the wallaby was of the avian type.

3. *Bovine Mastitis.*—The research work on this subject which has been proceeding steadily during the past two years may be considered under the following headings :—

(*a*) *Bacteria associated with Mastitis.*—In the course of the work it has been possible to make a bacteriological examination of udder secretion from 113 unselected cases of clinical mastitis. In each case records were made of the clinical characters of the disease. Eighty-two of the cases were associated with streptococci, 6 with staphylococci, 21 with *B. pyogenes*, 3 with coliform bacteria and 1 with *B. necrosis*. The characters of these bacteria have been studied in the laboratory with special reference to the streptococci.

(*b*) *Hemolysin and Toxin Production by Streptococci.*—The streptococci of mastitis in their effect upon blood may be divided into two groups, hemolytic and non-hemolytic. Observations have been made of the properties of the organisms in these two groups when growing in contact with blood.

In connection with the problem as to the relationship between mastitis streptococci and streptococci causing human disease, a study is being made of the toxin-producing capacity of mastitis streptococci. Some of the non-hemolytic strains have been found to be capable of producing filterable toxins in liquid media and these are now being compared with one another and with toxins produced by streptococci of human origin (scarlet fever toxin). So far no hemolytic strain originating in the cow's udder has proved capable of producing a useful toxin. Protection experiments in rabbits, however, using scarlet fever antitoxin, indicate no close relationship between hemolytic streptococci from mastitis and hemolytic streptococci from human sources.

(*c*) *Mastitis due to Staphylococci.*—Attention has been directed to a form of mastitis which is believed to be due to staphylococci. Although on the whole the condition tends to be mild clinically, in some herds it may be the cause of serious diminution in milk yield.

(*d*) *Diagnosis of Mastitis.*—In view of the fact that a small proportion only of cases of mastitis can be detected by clinical means, various laboratory methods have been proposed for making a diagnosis in occult cases. These include taking the reaction of the milk as it leaves the udder by means of brom cresol purple, observing the amount of deposit obtained by centrifuging a given volume of milk, microscopic examination of smears of this deposit for cellular elements and bacteria, and cultural examination of the milk. There has been abundant opportunity for acquiring experience of these methods and there is much evidence to show that the last named is by far the most efficient. Indeed, if reliance were placed upon a single examination by any of the first three methods, many cases of mastitis infection would remain undiagnosed.

In order to meet the possible objection that cultural methods, if applied in herds on a wholesale scale, would involve an excessive amount of labour, efforts are being made to devise means of reducing labour without diminishing the value of the procedure.

(*e*) *The Control of Streptococcic Mastitis.*—On the hypothesis that this form of mastitis is spread by the hands of the milker, control work is proceeding in five herds. The ultimate object is to determine whether the disease may be eradicated by the comparatively simple procedure of milking uninfected cows first. This work will be necessarily of long duration because there is reason to suppose that streptococcic mastitis may spread slowly even in the absence of all precautions.

4. *Johne's Disease.*—In consequence of numerous reports as to the increasing prevalence of this disease it was recently decided to commence research on the subject. Work is proceeding and will be referred to in future reports.

Travelling Fellowship.—Thanks to a grant from the Ministry of Agriculture, Mr. A. W. Stableforth, Senior Assistant in the Institute,

was enabled to spend two months in Germany on visits to various institutes. The main object of the tour was to collect information relating to bovine mastitis.

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24. DEPARTMENT OF ANIMAL PATHOLOGY, CAMBRIDGE UNIVERSITY.

In general, the work of the department has been continued along the lines detailed in previous reports.

Several investigations have been brought to a conclusion and other lines of work have been initiated.

Bacteriological.

Filterable Forms of the Tubercle Bacillus.—The investigation of this subject, undertaken in collaboration with Dr. A. Stanley Griffith, has been concluded. A series of experiments with tuberculous material from a number of sources and with cultures of the tubercle bacillus have failed to provide any evidence in support of the claims which have been made that a filterable form of this organism exists.

Work along similar lines with other organisms, such as *B. erysipelatus suis* and *B. suipestifer*, has resulted in a similar conclusion.

Epithelioma Contagiosum.—The study of this virus has been continued with special attention to cultural experiments. The virus has been propagated in tissue cultures with a fair measure of success. The reaction of the virus to various types of growing cells has been observed and some progress has been made in attempting to select the type most favourable for the cultivation of the virus.

Mastitis of Ewes.—Investigations of a preliminary nature into the etiology of this disease, which were begun in 1925, have been concluded. Several different organisms have been observed to be associated with the condition, and the more important have been typed. It would appear that there are several organisms capable of invading the udder tissue and producing the characteristic inflammatory changes. The bacteriological findings show that in this series of cases staphylococci are the commonest invaders.

Caseous Lymphadenitis of Sheep.—Work in connexion with the etiology and prophylaxis of this disease has been continued and several interesting facts have been established. It is clear that the Preisz-Nocard bacillus can withstand low temperatures over a long period—certainly up to two years—in infected material. It has also been shown that lambs and adult sheep can be readily infected experimentally by intravenous and subcutaneous inoculation and by the mouth as well as through wounds and by biting insects. Further, it would appear that there is a tendency for the infection to spread rather than to remain localised in neighbouring lymphatic

glands or in any particular tissue or organ as has sometimes been supposed. Finally, from the nature and dissemination of the lesions, young lambs appear to be much more resistant than adult sheep.

Six strains of the causal organism obtained from affected glands of imported carcases have been examined in respect of morphological, cultural, tinctorial and toxigenic properties. The viability of the organism has been studied as well as its virulence and pathogenic properties.

Anaerobic Diseases of Animals.—A general survey of the incidence of these diseases which was initiated some years ago is proceeding as facilities arise.

An outbreak of disease in a herd of young cattle involving the death of thirteen animals was found to be due to infection with *B. oedematiens.* There is evidence to show that this organism is a more important cause of losses among livestock in various parts of the world than has hitherto been supposed.

Enzootic Pneumonia of Cattle.—An investigation has been initiated into the etiology of a form of this disease which occurs annually in some districts. The condition, which appears to be of bacterial origin, is noted in the autumn shortly after the cattle have been brought in for the winter.

Bacillary White Diarrhoea.—An outbreak of B.W.D. in which the lesions presented many atypical features has been investigated, and the findings have been published.

Ulcerative Enteritis of Lambs. (Lamb Dysentery.)—This investigation is being continued as circumstances permit. During the past lambing season fifty lambs in which attempts had been made to set up the disease experimentally have been examined. Strains of *B. welchii* isolated from these and from a number of natural cases of the disease have been studied.

Immunological.

Epithelioma Contagiosum Avium.—In the continued study of this virus experiments have been carried out with a view to determining the relative values of different methods of vaccination against fowl pox.

Contagious Pustular Dermatitis.—Opportunity has afforded further facilities for the study of other strains of the virus. So far, they have been found to conform to the one type. It has not yet been found possible to arrange an extensive field trial with the protective material which has given such satisfactory results in experimental animals. It is hoped, however, that in the near future there will be an opportunity of doing so.

The Vaccination of Calves against Tuberculosis with B.C.G. Vaccine.—During the past twelve months the joint investigation carried out on behalf of the Medical Research Council and this department into the immunising properties of B.C.G. vaccine in

young calves has been continued. A considerable amount of work has been performed, chiefly with a view to determining whether a solid resistance can be induced, and if so the most satisfactory method of achieving this immunity. In these experiments the test dose has consisted of an intravenous injection of virulent bovine tubercle bacilli which kills untreated control calves within three weeks.

It was recognised that the test was severe, but it was felt that the method had certain advantages in that :—

(1) the actual amount of the test infection was definitely known ;
(2) animals which withstood such a test would almost certainly resist any (likely) form of natural infection.

Preliminary experiments have indicated that B.C.G. vaccine, when suitably administered, can produce a very high degree of immunity in calves as evidenced by their surviving the test dose.

This observation is of considerable importance in view of the widely divergent results obtained by other investigators.

The selected method of immunising is now being tested on a much larger scale in order to determine :—

(1) the reliability of the method ;
(2) the duration of the immunity ;
(3) the fate of the organisms used for immunising ;
(4) the fate of the organisms used for the test—whether given intravenously or acquired under natural conditions.

Biochemical.

The Influence of Gastric Nematode Worms upon Metabolism in the Sheep.—Interesting results have been obtained by recording the digestibility co-efficients and ingestion balances of the several components of the diet of sheep suffering from a heavy infestation with gastric nematodes. It is as yet too early to draw any definite conclusions, but there appears to be some evidence to show that, while the digestion and absorption of fat and carbohydrate are not affected, full use is not made of the protein.

Cellulose Digestion in the Ruminant.—At present, comparison is being made of the amounts of fibre digested in the ruminant and by the cellulose-splitting organism in vitro with a view to devising an "in vitro" method of determining the digestibility co-efficients of crude fibre.

Plant Poisoning.—Several investigations have been made into cases of plant poisoning of farm animals, especially poisoning of sheep by the Greater Celandine. In view of the importance of the subject, and the very scanty and often erroneous nature of our information in this connexion, it is hoped that in the near future facilities may be provided for the constitution of a complete team of workers adequately equipped to undertake these investigations.

The Mineral Content of the Bones of Young Pigs.—The comparative estimations of the mineral content of the bones of young pigs suffering from various diseases with that of normal animals have been continued.

Histological.

The Histopathology of Hypervitaminosis "D."—An investigation into the pathological effects of toxic doses of vitamin "D" (Irradiated Ergosterol) has been carried out in collaboration with Dr. L. J. Harris. Excessive amounts when fed to rats and rabbits produce lesions which are regarded as characteristic. Among these is an extensive deposition of calcium in various tissues of the body, especially in hyaline cartilage, kidneys and smooth muscle, concomitant with marked increase in the blood calcium. There is also atrophy of the spleen and thymus.

Comparison of these lesions with other pathological types (tuberculosis, arterio sclerosis) is of considerable interest since in this case there is no evidence of previous tissue necrosis. The condition of the thymus and spleen is in contrast with the hypertrophy of these organs observed in experimental rickets.

Ulcerative Enteritis of Lambs (Lamb Dysentery).—The histological study of the lesions of this condition has been completed with the examination of material from experimental animals during the past season, and a full report of the findings is being prepared for publication.

Physiological.

The principal lines of enquiry have been in connexion with the physiological properties of the anterior lobe of the pituitary, with special reference to its relation to problems of fertility and sterility.

The Basis of Follicular Development.—It has been definitely shown that extracts can be prepared from the gland which, when injected subcutaneously, stimulate intensely the production of follicles by the ovaries. There appears to be no limit to the number of follicles so produced if sufficient injections are made.

The possibility of the stimulating substance occurring in other tissues (e.g. the placenta) has received considerable attention, and methods for its extraction and purification have been elaborated with a view to producing it in sufficient quantities for use in the larger domestic animals. Apart from establishing the identity of this substance it has been necessary to ascertain its relationship to other substances extracted from the gland by various workers.

The Mechanism of Oestrus Inhibition.—Work commenced some time ago on the inhibition of oestrus by alkaline extracts of the anterior lobe of the pituitary has been completed. Contrary to the observations of other workers it has been found that single injections of small amounts of the extract will inhibit the cycle for periods which average those of normal pseudopregnancy. These results

have suggested a possible explanation of the role of the gland in normal animals.

The Mechanism of Ovulation in the Rabbit.—Following up the results obtained in rats it has been found that ovulation in the rabbit may be induced by the intravenous injection of extracts of the anterior lobe of the pituitary. Rupture of the follicles occurs at the same time after injection as after copulation. In collaboration with Dr. H. Florey, it has been shown that these results are obtained in the hypophysectomised rabbit.

Spontaneous Deciduomata in the Rat.—A study of these growths has been made. Contrary to the finding of other workers that they only occur during pseudopregnancy in animals on a diet deficient in vitamins "A" and "E," it has been shown that they can arise spontaneously in animals on diets rich in these vitamins when rendered pseudopregnant by injections of alkaline extracts of anterior lobe pituitary. Further, it has been shown that the growths can occur in animals which are not pseudopregnant but which are fed on diets deficient in the vitamins mentioned.

Sterility of Female Rats on a Diet Containing Excessive Amounts of Cod Liver Oil.—In collaboration with Dr. L. J. Harris a detailed investigation has been made into the sterility of female rats which occurs when they are fed on a diet containing excessive amounts of cod liver oil. It has been shown that failure to breed is not due to inhibition of the cycle or disinclination to copulate, but to the early resorption of the young. Implantation occurs but the embryos do not survive for more than ten days.

Parasitology.—A long series of experiments designed to determine the anthelmintic properties of a number of drugs against stomach worms in sheep has been completed.

The results of these experiments are, on the whole, disappointing since they have failed to reveal a reliable treatment for parasitic gastritis of sheep other than that caused by *Haemonchus contortus*. They confirm, however, the observations of other workers that there are several drugs available which are more or less effective against this worm. Of these copper sulphate would seem to be the best for general use, as it is cheap, safe, and can be easily administered either dry in capsules or in solution. Better results are obtained when two doses are given, and probably the interval of seven days between the doses could be shortened, with advantage, to one or two days. The addition of sodium arsenite did not increase the efficiency of the copper sulphate in these experiments.

Carbon Tetrachloride, given in 12 c.c. doses, would seem to be effective against *Haemonchus*. In such doses it is rather expensive, and although in these experiments toxic symptoms were not observed, deaths from smaller doses have been recorded by others.

Tetrachlorethylene (Nema) given in capsules containing 5 c.c. gave good results against *Haemonchus*. It caused marked constipation, however, and in a few instances post mortem examination

revealed some inflammation of the small intestine. The administration of a laxative with, or shortly after, the drug, therefore appears to be indicated.

Bunostomum trigonocephalum was found in three animals after the administration of this drug, which does not appear, therefore, to be effective for hook worm in sheep.

Petroleum ether gave promising results but further trials are necessary.

Turpentine, chloroform and linseed oil mixture, chloramine T. sodium pentasulphide and Monsol do not appear to be effective.

A proprietary copper and arsenic mixture, and copper with arsenic and muriatic acid did not appear to have any advantage over copper sulphate alone.

An investigation is being carried out along similar lines with the collaboration of several veterinary surgeons to ascertain the value of different drugs in the treatment of equine strongylosis.

In the course of routine examinations of material for parasitic worms several hitherto undescribed nematodes have been obtained from the stomach and intestines of kangaroos (*Macropus Woodwardi*) Detailed descriptions of these worms are about to be published.

Diagnosis.

Further observations are being made on the titration of a number of tuberculins in tuberculous bovine animals, with a view to confirming the value of this method as a means of determining the potency of tuberculin to be employed for the diagnosis of tuberculosis in cattle and of fixing a "standard."

Biological.

54,000 doses of various vaccines, etc., have been distributed to veterinary surgeons and stockowners mostly for field experiments. This amount includes 17,200 doses of an experimental vaccine for the prevention and treatment of "snuffles" in rabbits.

Routine Diagnosis.

3,588 specimens have been examined and reported upon.

Field Investigations.

Owing to the expense involved in carrying out these investigations the number has been greatly reduced during the past year.

25. VETERINARY LABORATORY, MINISTRY OF AGRICULTURE AND FISHERIES.

A. Foot-and-Mouth Disease Experimental Station, Pirbright.

(*Under the general direction of the Foot-and-Mouth Disease Research Committee*).

Work was continued on the survival of the virus outside the body, under various conditions, and also on the efficiency of disinfecting agents.

Observations were made on the survival of the virus in various animal organs and tissues, especially at low temperatures.

During the year the construction was undertaken of a refrigerating plant sufficiently large to permit the further study of the survival of the virus in meat preserved under ordinary trade conditions. This plant was completed, and a number of observations have been made, but further work is in progress.

A considerable number of field strains have been adapted to the guinea-pig, and observations have also been made on the re-adaptation of guinea-pig strains to cattle and pigs. A study has been made of foot-and-mouth disease in the rat.

The viruses which occurred during the year in (apparently) primary outbreaks in Great Britain were examined, and in most instances were assigned to their immunological type. This work confirmed that previously undertaken by Stockman and Minett, in that the great majority of the outbreaks in this country were shown to be due to viruses of the " O " type. A few viruses from Argentina were also examined.

Further studies were made of the first appearance and the decline of natural infectivity, in cattle infected by contact, and also of the duration of immunity, towards the same strain of virus, in cattle which had reacted to infection (natural or artificial), and which had then been protected from re-infection.

Some chemo-therapeutic work was carried out, but of the agents tested none appeared to exercise any useful influence on the course of the disease. In particular, it was found that the intravenous inoculation of iodine in relatively very large amounts was without useful effect, and it was not found possible to confirm the results obtained in Indian cattle by Walker and Taylor.

B. Veterinary Laboratory, Weybridge.

1. *Babesiosis and Anaplasmosis.*—New strains were established with the aid of infective ticks sent from Paris by Professor Brumpt.

2. *Scrapie.*—No new work was undertaken, but observations on the experimental flock were continued.

3. *Contagious Abortion.*—During the year 23,546 doses of vaccine were prepared and issued. Little experimental work could be

attempted, but certain field outbreaks were investigated. About one thousand agglutination tests were performed, in diagnosing outbreaks prior to vaccination.

4. *Tuberculosis.*—A study was made of the filterable virus of tuberculosis in the blood and milk of tuberculous cows. The occurrence of a filterable virus in avian tuberculosis is also under investigation.

During the year 1,120 doses of B.C.G. vaccine were prepared and issued in connection with the field trials in selected herds. The B.C.G. experiment undertaken at the laboratory during the previous year was completed, and all the calves were slaughtered. The results fully supported the claim that the vaccine is harmless to cattle, but under the particular conditions of this experiment the vaccine was not found to confer any significant degree of protection against natural infection. Further work on slightly different lines is contemplated.

5. *Swine Fever.*—Work has been carried out on the survival of the virus in bone marrow and muscle.

6. *Ostertagiasis in Sheep.*—The first field experiments in connection with the longevity of *Ostertagia* larvæ on pasture, and the effect of applications of lime and salt to the land, have been completed.

A careful analysis of an outbreak of *Ostertagiasis* in a pedigree flock, where fairly complete records were available, gave some interesting information on the importance of good feeding where a flock is in danger.

Laboratory experiments aiming at some means of destroying nematode eggs and larvæ in soil have been commenced. Eggs and larvæ of *Syngamus* are being used in these experiments, as they give a quick return and are relatively easy to handle.

7. *Life History of Moniezia.*—Field experiments have been continued.

8. *Ascariasis.*—An infection experiment in connection with the biological identity of *Ascaris lumbricoides* of human and of porcine origin has been commenced.

Experiments on the possible effect of *Ascaris* larvæ in aiding the invasion of the animal body by pathogenic bacteria are being carried out.

9. *Fowl Pox.*—The work which has been in progress for the past four years, with the object of finding a safe and reliable vaccine against this disease, is now yielding encouraging results. A live vaccine, which does not give rise to generalisation of infection, and which confers a considerable amount of protection, is now being prepared. This vaccine is being issued through County Poultry Instructors for tests on infected flocks, under field conditions.

10. *Avian Typhoid.*—This disease, which has hitherto been confined to Wales and the bordering counties, has recently appeared in some of the South-eastern counties of England. Over six thousand

doses of vaccine have been issued during the year, and in every instance its employment has given excellent results.

The laboratory experiments on this vaccine, to which reference was made in the last report, have been temporarily suspended owing to shortage of staff and suitable accommodation.

11. *Bacillary White Diarrhœa.*—Many articles have been published during recent years on an intradermal test for the detection of adult birds affected with bacillary white diarrhoea. Some writers have made exaggerated claims as to the accuracy of the method, while others have stated that the method was not reliable.

Extensive tests of this method, using various types of antigen, have recently been completed at the Ministry's laboratory. The conclusion arrived at was that the test was of some value, but much inferior to the macroscopic agglutination test, and, as practised at present, it could not be recommended. While it is perhaps improbable that it will ever be possible to devise an intradermal test which will be as reliable as the agglutination test, it is possible that on account of its simplicity the test may, with further improvements, prove to be of value in the eradication of bacillary white diarrhoea.

12. *Newcastle Disease.*—Cross-immunity tests have recently been completed with Newcastle virus and a virus which has caused heavy mortality among fowls in the Philippine Islands. The tests proved the two viruses to be immunologically indistinguishable.

Tests undertaken at the Veterinary Laboratory, Department of Agriculture, Philippine Islands, proved the Philippine virus to be immunologically indistinguishable from that which occurs in the Dutch East Indies, and which has caused disastrous losses. It would appear, therefore, that the diseases reported in England, Java, and the Philippine Islands are caused by the same filterable virus.

13. *Fowl Plague.*—Cross-immunity tests with various strains of fowl-plague have been carried out, but up to the present time no evidence has been obtained of the existence of different immunological types of the disease. Work has been performed on the survival of the fowl-plague virus in poultry carcases kept at low temperature.

Attempts to obtain a reliable vaccine against this disease have not, so far, proved very encouraging.

14. *Staphylomycosis in Pheasants.*—A disease in pheasants, associated with arthritis, was encountered on a large estate in Wales, and appeared to be due to a staphylococcus.

Attempts are being made to protect the birds against this disease with the aid of a vaccine.

15. *Poultry Diagnosis.*—During the year 2,744 specimens were examined, and about 30,000 agglutination tests for bacillary white diarrhoea were performed.

16. *Miscellaneous.*—In addition to the regular work of the Institution, much outside work has had to be undertaken.

Experiments have been conducted on a variety of subjects, including the presence in imported barley of some substance rendering the grain or meal unpalatable to pigs, and also acting as a moderate irritant to the gastro-intestinal tract.

It is of some interest to note, in connection with a newer branch of agricultural industry, that during the year inquiries and specimens have been received from a breeder of silver foxes.

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26. ANIMAL DISEASES RESEARCH ASSOCIATION OF SCOTLAND.

General.—In accordance with the existing policy, the major part of the work during the time covered by this report was devoted to "grass sickness" in horses and "lamb dysentery." In consequence of the results obtained during the last two years it is now possible to discontinue the intensive work on "lamb dysentery" and to give "louping-ill" a place in the research programme.

Braxy.—Some further observations were carried out during the winter of 1928–29 into the causation of this disease. A considerable amount of material was collected in the course of visits paid by members of the staff to the Taynuilt, Tushielaw, Newcastleton and Hawick districts. Owing to Mr. Preston's resignation and resultant pressure of work on the remainder of the staff, the examination of this material has not yet been completed. About 48,000 hoggs were vaccinated in the 1927–28 season, and about 54,000 doses were issued for use during the 1928–29 season.

Lamb Dysentery.—The advantage of grazing accommodation attached to the Institute has been very clearly demonstrated in the course of this investigation. If the Association had been in possession of such facilities from the beginning, the cause of "lamb dysentery" would have been clearly demonstrated some years ago, and the enormous losses suffered by farmers during the last decade would have been largely minimised.

Elaborate arrangements were made to carry out a set of experiments on new-born lambs on a larger scale than had been possible in the past, in order to find the causal agent of the disease. A hundred ewes and two tups were obtained from farms in Mull and in the Oban neighbourhood, which were free from the disease. They were kept at the Institute from September, 1927, on "clean" ground, and the lambing was so arranged that a succession of young lambs was available from the end of April to early in July. Healthy lambs were required as late as it was possible for them to be born, since affected material to work upon was not available until some time after the commencement of the hill lambing season.

The results reported last year were successfully confirmed with the first lambs born, and the later lambs were used for extension of the attempts to isolate the causal micro-organism.

Material from the field laboratory at New Luce, Wigtownshire, was despatched to headquarters daily. Duplicate bacteriological surveys of the flora of the faeces of lambs affected with the disease were carried out at the field laboratory and at the Institute, and, after sufficient work had been completed, selected micro-organisms were tested for capacity to produce dysentery when administered by the mouth to new-born lambs from the " clean " flock. All cultures yielded negative results, except those of one type of *Bacillus welchii*.

The results obtained in some experiments indicated that free toxin of the bacillus must probably be present before infection can be produced. This finding is of importance in connection with prophylactic measures to be adopted for the control of the disease.

Further work on the production of an immune serum was carried out, and it is now possible to confer a strong immunity on new-born lambs by inoculating them with such a serum.

" Grass Sickness " in Horses.—A considerable amount of work was carried out in connection with " grass sickness " during the period covered by this report. Numerous experiments were undertaken in the course of attempts to produce artificial cases of the disease. Numerous horses and other animals were used in the course of this work, and it now appears to be reasonably safe to state that it is impossible to produce " grass sickness " by inoculation with various tissues and fluids derived from the bodies of affected horses. Similarly it is impossible to produce the disease by feeding horses with large quantities of the content of various parts of the alimentary tract of naturally affected horses.

All the work carried out indicates that the disease is a form of intoxication affecting a special part of the nervous system. Two of the collaborators in this investigation have demonstrated that there is a degree of degeneration in the nerves supplying the organs affected in the course of the disease. The injury demonstrable in these nerves appears to explain the manner in which the various symptoms are produced.

This result suggests that a poison of some kind is at work, but there is still no indication as to the nature of the poison concerned. The scope of the enquiry is gradually becoming wider.

" Louping-Ill."—In the earlier years of its existence the Association had given considerable attention to " louping-ill," but had been unable to obtain any positive evidence as to the nature of the disease. Although " louping-ill " is probably responsible for more loss in Scotland than any other individual disease of sheep, it was felt necessary three years ago to cease work upon it in order that adequate attention might be given to " grass sickness " and " lamb dysentery." It is fortunately now possible to include it in the research programme. As a preliminary, the literature of the disease

has been surveyed, and a programme has been drawn up which should give some indication in the first instance as to the general nature of the disease and whether ticks are or are not responsible for its propagation. It will be necessary to clear up these and other matters before a more intensive study can be carried out.

In spite of the work already undertaken during the last half century, it is not possible to give any general opinion as to the nature of the disease. It is quite clear that there has been, and is, a great deal of misunderstanding as to what cases are to be admitted as "louping-ill" on affected farms. There is no doubt that the cases which clinically resemble "louping-ill" can be divided into at least four, and possibly five, categories, namely :—

(1) Lambs showing paralysis which is associated with suppuration in the neighbourhood of the spinal cord.

(2) Lambs showing symptoms of brain disturbances accompanied by the presence of indigestible substances ("wool ball") which have become impacted in the exit from the stomach or in the early part of the small intestine.

(3) Ewes showing brain disturbance or dysfunction of the locomotor system shortly before or after lambing.

(4) Cases of paralysis and brain disturbance in lambs or in sheep of older ages in which there is neither suppuration in the neighbourhood of the spinal cord, nor impaction in any part of the alimentary tract.

(5) Cases due to other causes.

It is the cases under head (4) which include true "louping-ill." Cases under heads (1), (2), (3) and (5) will not be given any direct attention in the course of the enquiry.

Bovine Abortion and Sterility.—A scheme for a special investigation into bovine contagious abortion has been submitted to the Department of Agriculture for Scotland. The work detailed in the scheme is estimated to cost about £7,000, and will involve the whole time of one investigator for about five years.

"Transit Fever."—The Ministry of Agriculture asked the Association to undertake some investigations into this condition. Owing to shortage of staff it was not possible to do more than make a few preliminary enquiries. There does not appear to be any reason to believe that "transit fever" is a specific infective condition brought from the farms of origin. The cases occur in cattle obtained from different parts of the country, and appear to be connected with the rigours of the journey from the farms of origin to the new homes. The question has been under the consideration of the Research Committee, which has recommended that a preliminary survey into the hygienic aspects of the question be undertaken. An application has been made for funds in order that Professor Linton of the Royal (Dick) Veterinary College may carry out this preliminary enquiry into the hygienic conditions.

" Scrapie."—A considerable number of " scrapie " experiments are now in progress at the Institute. The Animal Breeding Research Department of Edinburgh University has been asked to collaborate in the investigation. The Association was fortunate in that it was possible for Mr. W. C. Miller of that department to help in one set of experiments requiring surgical procedure, designed to shed some light on the manner in which the disease is propagated.

Bovine Tuberculosis.—The experiments on the use of Calmette and Guerin's vaccine were continued on the same farms as in former years.

Miscellaneous.—A good deal of autogenous vaccine for bovine contagious mammitis is prepared each year.

Supervision of the experimental animals and miscellaneous routine work in connection with diagnosis and advice concerning obscure diseases, takes up the whole time of one member of the Research staff.

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27. MILK FEVER INVESTIGATIONS, ROYAL (DICK) VETERINARY COLLEGE AND HANNAH DAIRY RESEARCH INSTITUTE.

(1) A complete survey of the British literature on milk fever has been made, including a bibliography of some 140 references.

(2) A number of further cases of milk fever have been investigated. The fall in blood calcium has been amply confirmed, and evidence is now accumulating that hypocalcaemia is the *primary* cause of the disease.

(3) Injection of calcium salts, exclusive of mammary inflation, has been shown to effect a complete cure. Similarly, injection of calcium salts immediately after calving prevents the disease.

(4) The oral administration of large doses of vitamin D has been shown to raise the blood calcium. The possibility of this treatment as a preventive measure is being investigated.

(5) The nature of lambing sickness has been investigated and it has been shown that this disease is also due to an acute hypocalcaemia. The pathology of lambing sickness is to be regarded as identical with that of milk fever. This discovery will, *inter alia*, enable use to be made of sheep as experimental animals in future work. Calcium injection has brought about rapid recovery in lambing sickness.

(6) Professor Greig has shown that Transit Tetany in mares is associated with acute calcium deficiency (two cases). Calcium injection in one case and mammary inflation in the other resulted in rapid recovery.

(7) A large number of blood calcium determinations has been carried out including 28 cases of normal sheep, 25 cases of normal horses, and 130 other cases of disease other than milk fever. Although in some disease conditions a low blood calcium was observed, in no case was a calcium value found in any way comparable with those which occurred in milk fever, lambing sickness, and Transit Tetany.

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28. ANIMAL DISEASES DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Research work on contagious abortion and sterility was continued. Several outbreaks of abortion were encountered where agglutination tests for Bang's disease gave negative results. The causation of these cases is being examined.

Investigations were in progress regarding the flora in metritis, which is the commonest cause of sterility in cows.

Experiments to determine the etiology of "headles" in sheep entered on their third year. The indications are that the disease is caused by a plant with photodynamic properties. Suspected plants were again fed to lambs with negative results. Attempts to transmit the disease failed.

Investigations in poultry diseases were almost entirely confined to bacillary white diarrhœa. A selective medium for *B. pullorum* was employed which facilitates diagnosis and research work on the disease. A paper is being prepared on the subject.

Much time was devoted to the technique and interpretation of the agglutination test for bacillary white diarrhœa. A comparative study was made of the various methods employed at other laboratories and marked variations in the results were obtained.

Experiments to determine the method of spread of bacillary white diarrhœa amongst adults were continued.

G.

ANIMAL NUTRITION
and
ANIMAL BREEDING.

29. ANIMAL NUTRITION INSTITUTE, CAMBRIDGE UNIVERSITY.

During the past year the sheep feeding experiments of Professor Wood referred to in the last report have been continued on the same lines. It is hoped that during the present year the experiments may be brought to a conclusion, at any rate, for the time being. Further information as to the maintenance and production requirements of sheep of all ages has been obtained.

Mr. Foreman has continued his scientific investigations of the chemical changes occurring in certain species of grasses and clovers. The problems are approached on new lines rendered possible by his past work. Throughout the course of the growth the relations between changes occurring under different environmental conditions and the nutritive value of the produce have been kept under review. Already it may be stated that the results appear to throw great light upon certain growth processes and lead to conclusions of immediate practical importance. Attempts are being made to widen the grass investigation as far as possible in order to test the probability that conclusions so far reached in regard to the species studied may follow in the case of the whole of the Gramineae including the cereals. At the present stage the results are of such promise that it seems highly desirable to investigate cereal growths on the same lines without delay. Progress with the work, however, must be governed by the extent to which suitable assistance is made available.

In regard to the section dealing with the nitrogenous constituents, the difficulty of preparing reliable specimens of the proteins of grass and clover tissues in more than minute quantities has been overcome. A new method has been evolved which gives good yields of these substances apparently quite in their native state.

Dr. H. E. Woodman and his co-workers have continued their investigations into the influence of the intensity of grazing on the yield, composition and nutritive value of pasture herbage. In a paper published in conjunction with Mr. D. B. Norman and Mr. J. W. Bee, he has shown that pasture submitted to a system of three-weekly cuts, though slightly less rich in protein, is nevertheless equal in respect of digestibility and nutritive value to grass grown under weekly or fortnightly systems of cutting. At the end of three weeks' unchecked growth, pasture grass still consists of non-lignified, highly digestible tissue as at the end of a week's or of a fortnight's growth. Since the characteristics of high digestibility and nutritive value are maintained, by cutting every three weeks, over the whole season, it is inferred that similar results would follow from a system of rotational grazing, where the pasture enclosures, after being thoroughly eaten down by stock, are permitted a three weeks' interval of unchecked growth before being grazed down again. The investigation demonstrated further that if the management of the experimental pasture had been attempted along the lines of close grazing

under the weather conditions of 1928, a simple division of the main field into a suitable number of smaller enclosures, for rotational grazing at three-weekly intervals (i.e. a three-weeks' "rotational close-grazing" system) would have enabled the stock-carrying capacity of such unfertilised pasture to be increased in the ratio of 2 : 3. During the 1929 season, Dr. Woodman, with the assistance of Mr. D. B. Norman and Mr. M. H. French, has carried these investigations a stage further by the adoption of a monthly system of cutting. The results of this later trial are being prepared for publication.

During the past year, Dr. Woodman, with the help of Mr. Underwood and Mr. Norman, has started an extensive series of trials to test the influence of intensive fertilising on the composition (chemical and botanical) and yield of cultivated pasture. It is intended that these experiments shall continue over a number of years.

Experiments have also been carried out by Dr. Woodman, in collaboration with Mr. J. W. Bee and Dr. G. Griffith, to test the effect on digestibility and nutritive value of conserving young pasture grass by the method of artificial drying (*a*) at 100 per cent. by means of steam, (*b*) by direct heat in a kiln. An account of these experiments is in the Press at the time of writing.

Drs. Woodman and Stewart have continued their investigations into the mechanism of cellulose digestion in the ruminant organism and have demonstrated that cellulose can be transformed into glucose by the controlled activity of cellulose-splitting organisms. These workers are now studying the action of cellulose-splitting bacteria on the fibres of different feeding stuffs with the object of elaborating artificial methods for (*a*) measuring the digestibility of the fibre of different foods, (*b*) following the process of lignification in green crops.

During the past year, Dr. Woodman has completed his investigations into the nutritive value of sugar beet pulp. Following his work on the feeding value of sugar beet pulp for ruminant animals, he has, in conjunction with Mr. A. N. Duckham and Mr. M. H. French, investigated the value of dried sugar beet pulp and molasses sugar beet pulp in the nutrition of swine. The same workers have also investigated the value of whole sugar beet in pig feeding. With the collaboration of Mr. A. J. Codling, Dr. Woodman has also completed an investigation into the pectin content of sugar beet pulp and has studied the properties of beet pectin with a view to ascertaining its possible value in such technical processes as the manufacture of jams and fruit jellies. Accounts of these separate investigations are in the hands of the printers at the time of writing.

A paper has been published by Dr. Deighton giving an account of much of the work done in the calorimetry department since the erection of the new calorimeters. Its principal immediate agricultural interest is in its raising the question as to whether the different breeds

of pig may not differ materially in the magnitude of the maintenance ration they require.

Having in view the results published in the above paper, the matter has been taken in hand and a scheme of work mapped out which will absorb the major energies of the department for some years ; this is, namely, the study of the metabolism of all the usual breeds of pig at all ages between weaning and maturity. The work is to be done in duplicate and in some cases in triplicate. A beginning has been made with this programme and the work is so far progressing satisfactorily : there are at present some ten pigs of various ages under experiment, but as will be understood from the paper quoted, the results cannot accrue until a constant metabolism per square metre is established in fasting and this has not yet happened. Meanwhile much material confirmatory of work previously published from this laboratory is accumulating in the matter of Effect of Environmental Temperature on Fasting Katabolism in Pigs.

Mr. Catchpole has been engaged in the construction of a small calorimeter for rats with a Dewar flask as the chamber. This he has completed as far as securing a correct record of heat is concerned ; apparatus for dealing with water vapour has still to be added and this work is now being taken over by Mr. Emms on the departure of Mr. Catchpole to other work. Mr. Emms intends to use this calorimeter and another of rather larger size, which he is making on the plan of the larger ones, for the study of the effect, if any, of skin colour on metabolism, and some of the pigs comprised in the experiments mentioned above have been selected also with a view to affording him further material on which to base conclusions in this matter.

Since Mr. Morgan severed his connection with the department Mr. A. D. Lauchlan has been assisting Dr. Deighton with the general work and took charge of the instruments and experiments for six weeks during the summer when Dr. Deighton was away in Europe visiting various laboratories employed in similar investigations.

Physiology of Reproduction and Growth.—Mr. Hammond's investigation on the oestrous cycle and fertility in horses is being continued. The length of the " heats " and the intervals between them are being recorded with a view to studying the conditions which influence the appearance of " heat." A rather unexpected result was that quite a large proportion of the mares continue to come on heat regularly throughout the winter. Matings with a fertile stallion, to find out the chances of fertility of a mating made early or late in heat, are being made at present only during the normal breeding season (March–July). While larger numbers are yet required to make absolutely certain of the results, there is an indication that service late in the heat period is the most likely to be fertile. The results obtained up to the present time are as follows : Of seven mares served during the last three days of heat five (71 per cent.)

have been in foal; of three mares served during the 4th–6th days before the end of heat one (33 per cent.) has been in foal; while of six mares served over six days before the end of heat only one (17 per cent.) has been in foal.

The stock of various lines of inbred rabbits has been maintained for studying problems in growth and fertility. During the course of such work it has been found necessary to follow the practical problem through several sciences, in addition to that of physiology, in order to obtain a well-balanced account, the relative importance of the different factors affecting fertility and growth being an essential to a study of the economic problems concerned. It has been found, for example, that animals producing large litters can be obtained by crossing a strain which is low in fertility from one cause (a small number of eggs shed) with one which is low in fertility from another cause (embryos perishing before birth). The experiments on controlling the number of young born by regulating the time the mating is made in relation to the time the eggs are shed, which have been in progress for the last three years, are now almost completed. The above-mentioned work is being continued by Mr. Hammond who is also engaged in further work on the ferret.

Thus, in the absence of facilities for keeping the larger farm animals, the results obtained in the control of fertility in the rabbit are being checked by testing the methods on the ferret; during the year a trial has been made of how long the eggs remain capable of fertilization after they are shed, and small litters have been produced towards the end of this time, just as in the rabbit.

Observations on the carcases of cattle, sheep and pigs at the Smithfield and Dairy Shows have been continued by Mr. Hammond. He has also made a survey of the part played by the environmental conditions of climate and feeding in shaping both the individual and the breed for the specialized production (of meat, milk, butter, cheese, etc.) which form the economic basis for the localization and specialization of animal production in different districts.

Dr. Walton has completed his investigation on the effects of temperature on the vitality of rabbit's sperm and it has been written up for publication. The effect of keeping the sperm in the epididymis of the male outside the body has been compared with its life in glass tubes. Experiments have also been completed on the means by which the sperm make their way from the vagina up the female tract.

During the year Dr. Sanders' enquiry into the relative importance of maximum yield and persistence of yield, in determining total lactation yield, has been carried forward and completed; owing to pressure of other work it has not yet been possible to finish preparing this material for publication.

In December, 1928, it was decided to collect data bearing on the "wastage" of dairy cows, and Mr. Hunter Smith and Dr. Sanders were deputed to initiate a scheme for the Province. With the aid of

County Organisers, Secretaries of Milk Recording Societies, and others, a scheme was eventually agreed upon, and now appears to be working satisfactorily. All the herds (except one) in the Bedford, Cambridge, Hertford, Lincoln and Norfolk Societies are included, and details of every cow sold or died since October 1st, 1928, have been collected. Since the inception of this enquiry it has been decided, at a meeting at the Ministry of Agriculture, to cover the whole country with one general scheme ; the scheme adopted was substantially the same as that in operation in the Cambridge Province, so that the work already started will be continued as part of a wider survey.

Poultry Nutrition.—The work of this section, under the general guidance of Mr. Halnan, is directed towards the evolution of a scientific basis for the feeding of poultry and the study of physiological and biochemical problems ancillary thereto. During the year under review, digestibility studies on oats and bulrush millet have been carried out. Oats have been shown to exhibit varietal differences in digestibility, thus emphasising the necessity of considering the nature of the variety of oat used for poultry feeding. In the three varieties tested, Grey Winter proved the best variety, Black Bountiful the next best, and Scotch Potato proved the worst. The digestibility study of bulrush millet (*Pennesetum typhoideum*) was carried out as the result of an application from the Empire Cotton Growing Corporation and this cereal of Empire origin proved to be suitable for feeding to poultry in all stages of growth. On a digestibility basis, bulrush millet appeared to be equivalent to Little Joss wheat in feeding value.

The influence of the size of a ration on its digestibility has also been studied, and it would appear from the results obtained that small and large rations are equally efficient as a source of food nutrients to poultry.

As the result of a study of the scientific data available, and by correlation of these data with the results of egg-laying trials carried out in different parts of the Empire, a tentative feeding standard for egg producing birds has been published.

As the result of a request from the British Game Farmer's Association, an attempt has been made since 1928 to evolve a satisfactory ration for rearing pheasants. Progress in this work has been hindered through management difficulties., but the results of the last year's rearing have encouraged the hope of eventual success. This year, seven pheasants were successfully reared to maturity under conditions of artificial incubation and rearing.

During the period under review Dr. E. M. Cruickshank joined the staff as Research Assistant, this fresh appointment being made possible as the result of funds placed at our disposal by the Empire Marketing Board.

30. ROWETT RESEARCH INSTITUTE, ABERDEEN.

The research work during the year 1928–29 has been mainly an extension of the work previously reported. The main investigations on which the Staff of the Institute are engaged are of such a nature that the work must be carried on for several years before sufficient data are available to enable definite conclusions to be drawn. There is consequently a close similarity between the report for the present year and that for the preceding year. The developments in the various lines of work are indicated below.

Pasture Investigation.—The special investigation which was being carried out in Kenya Colony has been completed. A confidential report has been submitted to the Civil Research Sub-Committee under whose general supervision this work was carried out. The report for publication is in course of preparation and will be available at an early date.

The data which are being dealt with in this report seem to indicate that in districts where there are deficiencies in the pastures, the feeding of relatively small amounts of what is deficient is followed by increased milk yield in dairy cows and, in the case of sheep, increased rate of growth of lambs and increased weight of fleeces.

The work in Kenya is being developed and extended on the Government Experimental Stock Farm. It will, however, be at least three years before further results of practical interest are obtained.

The work on similar lines on the hill areas of Scotland is being continued. The main feature of interest in the past year's work has been in connection with the wintering of ewe hoggs. The usual practice is for these animals to be sent away to the low country for wintering which involves a cost of about from 10s. to 15s. per animal. During the last winter, four groups of 20 ewe hoggs were kept on the hills and given about an ounce per head per day of a special feeding stuff. The result on the whole was satisfactory and some groups are being kept this winter under more exact conditions which will enable determinations to be made of variations in weight throughout the winter. The data accumulated during the last winter showed that there was a remarkable loss of weight both in the animals kept at home and in those which were wintered on the low ground.

These sheep experiments, which in the past years have been carried out in various parts of Scotland, have now been, for convenience, centred in the Island of Arran. A committee of sheep farmers has been formed to assist with this work and to give guidance especially on the practical and economic aspects of the problem. The members of the committee are providing the sheep for the tests and giving active assistance in the carrying out of the work.

The experiments on the effect of successive applications of sulphate of ammonia and rotational grazing on the stock carrying capacity and on the chemical and botanical composition of pastures

have been continued. The present year's results are in the main in accordance with those previously noted, viz., that this intensive method of management of pastures markedly increases the carrying capacity and that the sulphate of ammonia tends to increase the length of the grazing season. It is intended to carry on this experiment for a further year to note the effects of several years' treatment of the pastures and also to get sufficient data for costings.

The investigation with small plots to show the effect of frequent cutting as compared with cutting for hay, has been repeated. The chemical analyses of the samples of the various plots are being carried out. The data from these plots are being submitted to a committee representing the Nutrition Institute, Cambridge, and various other Agricultural Institutions where similar experiments are being carried out. It is anticipated that the data from all these centres will be considered together by this committee and, if of sufficient public interest, be made the subject of a special report.

Mineral Metabolism.—The feeding experiments with pigs, cattle and poultry, to test the effects on nutrition of the addition of various amounts of iodine to the ration have been continued. It is intended that these experiments shall run for several years to enable the effects to be observed throughout the complete life cycle of the animals, and also on their offspring.

The chemical work to determine the iodine content of foodstuffs in goitre areas has been completed and the data are being worked up for a report which will be submitted in the first instance to the Committee of the Medical Research Council.

During the past year work has been begun to determine the role in nutrition of various metals which are present in very small quantities in most foodstuffs and in animal tissues. Manganese, aluminium and copper are under investigation. The work so far has consisted of the determination of the amounts of these present in the commoner foodstuffs and in the various organs and tissues of the body, and in feeding experiments with groups of animals to determine the influence of varying amounts of these in the diet on the rate of growth and health of animals.

Intestinal Movements.—The results of work already reported have shown that certain deficiency diets tend to produce ulcers in the stomach or duodenum. There was some evidence that the defective diet disturbs the normal rhythmical movements of the intestine and that this disturbance of movement is an important etiological factor in producing ulcers. Studies with isolated loops of intestine seemed to indicate that the disturbance of the rhythmical movements might be associated with disturbance of certain ductless glands, especially the adrenals. In the course of this work observations have been made on the difference in the rate of diffusion of certain substances through the wall of the living and of the dead intestine. The results of this work during the past year have, on the whole, been almost entirely of academic interest and they have been published in a

series of technical papers. The practical significance of the results, however, is not yet clear and observations are now being made on the movements of the intestine in the living animal.

Nutrition and Disease.—In a number of feeding experiments it has been noted that disease, apart from nutritional disorders, is more prevalent in groups of animals on deficient diets than in the groups receiving a complete well-balanced ration. During the past year some work has been done upon rabbits and guinea pigs, to determine whether certain deficiencies in the diet had an influence on the composition of the blood and on the susceptibility to tuberculosis. The results, so far as they went, suggested that in the case of young growing animals, deficiencies in the diet of calcium and of factors affecting the assimilation of calcium, e.g., Vitamin A, affect both the calcium content of the blood and the resistance to the infection of tuberculosis experimentally introduced. The effects were, however, less marked in the case of full-grown animals. This work is being continued and developed with farm animals in co-operation with the Bacteriology Department of Edinburgh University and the Animal Diseases Research Association.

Arising out of the work on anaemia previously reported, further work has been done during the course of the year on the nature of the bilirubin present in the various types of jaundice and its chemical reactions, especially in relation to the alkali reserve of the blood and also on the absorption and excretion of iron by the intestine and its significance in nutrition and therapeutics. Work has also been done on the biological nature of the mesenchymatous tumours in fowls, and an investigation has been carried out on the biological significance of chloroform poisoning, especially in relation to fat, calcium and sugar metabolism. The results of these investigations so far are mainly of academic interest, and are being published in a series of technical papers.

Endocrine and Blood Changes in the Life Cycle of the Fowl.—Observations have been made on the composition of the blood, and on the condition of the thyroid and ovaries in the fowl during the period of growth, laying and moulting to determine whether there was any detectable change in the blood or in these organs which could be correlated with the onset of laying and moulting. The only definite result noted was a marked increase in the calcium of the blood before the onset of laying and a decrease in moulting. Certain changes in the thyroid were suggestive, but not sufficiently definite to enable any conclusions to be drawn. Further work on these lines will be continued during the present year.

Duthie Experimental Stock Farm.—During the year further progress has been made with the establishment of this farm. It is expected that by the summer of 1930 the erection of the buildings for the sheep and beef cattle departments will have been completed. The other departments of the farm were finished last year.

Certain practical experiments in connection with pigs, poultry and cattle have been carried out to test, e.g., the effect of various food factors on the size and number of eggs produced in fowls and on the rate of growth of pigs and calves. The work on poultry has been carried on in conjunction with the Department of Agriculture of Northern Ireland and the Scottish Colleges of Agriculture. The work on pigs has been carried out in conjunction with a committee representing England, Scotland and Northern Ireland, and the work on calves in conjunction with the East of Scotland College of Agriculture. The results of these experiments have been published in the Journal of the Ministry of Agriculture and of the Department of Agriculture for Scotland.

The main work of each of the Departments of the Farm, however, during the first two years is to obtain data to show the rate of growth of the various types of animals and the cost of production of the various products, e.g., milk, eggs, pigs, on good rations, and under normal good farming conditions. It is intended that the results obtained during the first two years will form the basis of future work.

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31. (CHEMICAL AND) ANIMAL NUTRITION DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Poultry Nutrition.—Feeding experiments with young chickens carried out in 1928 demonstrated the value of separated milk and indicated that this value is due, to a large extent, to the easily assimilable minerals which it contains. A group of chickens reared on a mash designed as a substitute for the separated milk ration gave completely satisfactory results.

These experiments were repeated and extended in 1929 and confirmation of the previous year's work was obtained. A cheaper and less complicated mash than that used in 1928 provided an equally efficient substitute for the separated milk ration.

Nutritional experiments with laying birds have been continued both from the point of view of effect of rearing on subsequent egg production and the influence of the protein and mineral content of the ration on egg yield and egg weight.

Pigs.—Several experiments have been carried out to determine the effect of various feeding stuffs on the quality of bacon and a method of comparing the firmness of bacon fats has been elaborated. In one experiment a comparison was made between rations containing maize meal, tapioca root flour, ground oats and barley meal. There was little difference in the rates of growth of the four groups of pigs and it was found that the fat from pigs fed on tapioca root flour and ground oats compared favourably with that from pigs fed on barley meal.

Sheep.—Mineral feeding experiments with hill sheep are being continued.

Composition of Milk.—With the object of exploring the causes of the variations in the composition of milk from dairy cows, samples, morning and evening, from individual cows of the dairy herd at the Agricultural Research Institute, Hillsborough, are being examined and records kept of climatic and other factors. It is hoped, with the help of this data, to trace the factors influencing the quality and quantity of milk produced by individual cows.

Pollution of Rivers with Flax Water.—An investigation was undertaken to ascertain the nature of the products present in flax water which are responsible for its poisonous nature. The results of analyses of a number of flax waters and numerous experiments with fish, both in the field and laboratory, indicate that the high dissolved carbon dioxide content and acidic nature of the ret water is largely responsible for its toxic character.

Adulteration of Butter.—Determinations of the Reichert-Meissl Values of butters from various sources at regular intervals are being made with the object of obtaining information as to the validity of the present presumptive standard at certain times of the year.

Baby Beef.—A feeding experiment designed to obtain information as to (*a*) the control of the " bulk " of the ration and (*b*) whether it is possible to increase the proportion of home grown food in rations for baby beef has been carried out. The results indicated that a ration containing a high proportion of purchased cakes was not superior to one containing more home grown foods and consequently a lower protein value. Two further experiments on these points are in progress.

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32. PIG HUSBANDRY EXPERIMENT STATIONS.

A.—HARPER ADAMS COLLEGE.

Experiments completed during the year deal with the normal variability of the average growth rate in lots of ten pigs each ; the economic value of whole milk, separated milk, and soya meal in pig-feeding ; the comparative values of tapioca flour and maize ; the use of dried sugar beet pulp as a substitute for sharps ; and the optimum proportions of different high-protein feeds.

The variability experiment indicated that a minimum significant difference of roughly 12 per cent. of the average live-weight gain must be assumed in assessing the results of experiments carried out under the conditions of housing and management obtaining at the station. The milk experiment was one of a series carried out in conjunction with other centres, and the results have been embodied in a joint report. They suggest that whilst the feeding of whole milk was distinctly uneconomic, separated milk could be used with considerable economic advantage under the price conditions prevailing at the time of the experiment.

In the tapioca experiment results were obtained definitely confirming the conclusions drawn from an earlier experiment that tapioca meal is practically equal to maize meal in nutritive value, and gives a bacon of higher quality. The cost of feeding was also substantially reduced.

The experiment with dried sugar beet pulp was preliminary in character and gave indications that, subject to certain technical difficulties in feeding, the dried pulp might form an effective and cheap substitute for a considerable proportion of the sharps used in pig-feeding. These indications have been subsequently confirmed in a further experiment.

A comprehensive experiment, supplementary to previous studies of the optimum proportions of high-protein feeds used along with a basal cereal ration, gave results entirely confirmatory of the earlier conclusions that the optimum proportion lies between 5 and 10 per cent. of the total ration, whether the high-protein feed be soya meal (+minerals) or fish meal.

It is claimed that the work of the station has effected an appreciable reduction in pig-feeding costs through the demonstration of the suitability and value of soya meal, beet pulp and tapioca meal.

B.—SOUTH-EASTERN AGRICULTURAL COLLEGE.

The food consumption of Middle White pigs kept upon the indoor and outdoor systems was compared during the months of November, December and January. The food consumption of both the indoor and outdoor groups was the same during November. In December and January the outdoor group consumed 60 per cent. more food than the indoor group for each 1 lb. live-weight increase.

The improvement effected by running pigs on grassland was measured by taking a crop of hay. The land on which pigs had been penned produced 57 per cent. more hay than the controls in spite of the fact that part of the area which carried pigs was badly trodden and produced no crop.

The value of milk from cows which reacted to the tuberculin test as a food for pigs of 30–80 lbs. live weight was found to be 5*d*. per gallon (one experiment only). The milk was pasteurised before feeding.

Four-ply paper bags were tested and found to be suitable containers for pig food.

A survey was made of pig-keeping in the County of Kent, the conditions under which pigs were kept and the methods of management employed being studied.

33. NATIONAL INSTITUTE OF POULTRY HUSBANDRY, NEWPORT, SALOP.

The research section of this branch of the National Poultry Institute Scheme continues to deal primarily with problems of production of importance to poultry farmers and rabbit producers, especially those handling large units. As is its function, it has in a number of cases taken over problems which have been studied in their initial stages at other research stations. It aims to take fundamental facts, theories or recent discoveries as well as new practices that show promise of commercial usefulness and to study their economic value.

Poultry Husbandry.

Confinement and Vitamin D Studies.—During 1927–1928, experiments with Single Comb White Leghorns conducted by Mr. Bobby showed that laying hens confined behind ordinary glass windows, and fed with the usual ration not containing the vitamin factor, would develop adult rickets and would give decreased egg production at the end of two to three months. Access to runs, the use of a protected open-fronted pen and cod liver oil supplied the necessary food accessory, the absence of which appeared to result in a decrease of egg production.

During 1928–1929, similar experiments with White Wyandottes conducted by Miss MacFadzean confirmed these results. A report by the Director has shown that White Leghorn laying hens confined behind glass and given cod liver oil at the rate of 1 per cent. of tested cod liver oil in the ration (2 per cent. of the scratch food) gave better egg production during the winter months than those with free access to runs and not getting cod liver oil. Laying hens not confined or in open-fronted houses did not develop adult rickets. The addition of irradiated dried skim milk to the ration did not supply sufficient vitamin D to prevent rickets. Further experiments are now being conducted to find out if the addition of tested cod liver oil to the ration of unconfined layers will prove beneficial. A comparison is also being made of irradiated Ergosterol and tested cod liver oil as sources of vitamin D for laying hens.

Mr. Lomax has shown in experiments with Vitaglass, Cellophane and Window Glass that chicks confined behind Vitaglass made better growth and maintained better health during a ten weeks period than those confined behind Cellophane or window glass. The use of Cellophane did not give sufficiently good results to justify its use.

Protein Studies.—The Director and Mr. Lomax have completed a two-years' experiment with certain animal and vegetable protein feeds with and without mineral supplements. The comparisons included Fishmeal, Meatmeal (60 per cent.), Meatmeal plus a mineral mixture, Extracted Soya Bean Meal plus a mineral mixture, and Decorticated Earthnut meal, plus a mineral mixture. The Fishmeal

and Earthnut meal pens gave lower productions, but the differences between any of the productions were not significant in either year, or in the two years combined. The Fishmeal pen gave a significantly larger egg weight for the two years combined over the Earthnut meal pen only. There was no significant difference between any other two pens.

Methods of Feeding.—Comparisons made of methods of feeding during the two years just past show no significant differences between the dry mash and wet mash methods of feeding. The all-mash method of feeding has shown sufficiently promising results to justify its use for growing chicks and further extensive studies into its use for laying hens are being made.

Sex Linkage.—A cross between a Black Minorca male and White Leghorn females failed to show sex linkage at hatching or sufficiently early to be of economic importance.

Extension of Research.—During the past year, new facilities have been developed under a grant from the Empire Marketing Board. New studies dealing especially with egg quality, and table poultry production have been started.

Rabbit Husbandry.

Growth Studies.—Mr. King Wilson has completed a study of the normal growth curves of certain breeds of rabbits kept for wool or fur. Methods of feeding rabbits and a number of rations for rabbit feeding have been compared.

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34. SMALL ANIMAL BREEDING RESEARCH INSTITUTE, CAMBRIDGE UNIVERSITY.

The experiments referred to in previous reports have made steady progress during the past year. An item of interest has been the formation of a breed of poultry showing sex linkage within the breed. This may be expected to have considerable economic importance when properly developed.

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35. ANIMAL BREEDING RESEARCH DEPARTMENT, EDINBURGH UNIVERSITY.

In the field of applied science much work has been carried out through the generous co-operation of farmers and breeders throughout the country, particularly in the investigation of sheep problems.

Cattle.

(*a*) *Shorthorns.*—A study has been made of the part inbreeding has played in the construction of the modern Shorthorn, especially as regards the prizewinners of the Scotch or Beef type and the part that various sires have played in the creation of the present day type of animal. It was found that the prizewinners are slightly more inbred than the average of the breed, though not significantly so. More interesting results were obtained when the individual pedigrees and types of mating were studied. These clearly showed that certain immediate ancestors were more likely to beget prizewinners than others.

(*b*) *Jerseys.*—A similar study has been made of Jersey cattle. The amount of inbreeding in the construction of this breed has been comparatively small. A study of the pedigrees of the high yielders revealed the fact that these were significantly less inbred than the average of the breed.

(*c*) *Inheritance of Milk Yield and Quality.*—From the above facts as well as from other data, the deduction was made that certain of the factors governing the inheritance of total yield as well as quality of milk were not inherited in the common autosomal manner but appeared to be inherited in a sex-linked manner. Evidence from workers in America supported this belief. Further studies of a statistical nature were accordingly undertaken and are still in progress. The material for these studies consists of pedigree Ayrshire cows recorded in the Annual Report of the Scottish Milk Records Association. The results so far obtained confirm the impression that some of the factors governing milk inheritance are sex-linked. This statement cannot be accepted as proved until further data are available and work is progressing along these lines. Much assistance in these studies has been obtained from Dr. R. A. Fisher, F.R.S., of Rothamsted and also from Mr. McCandlish of the West of Scotland College of Agriculture.

(*d*) *Average Age of Sires and Dams.*—A study of the average ages of sires and dams in six pedigree breeds is nearing completion. The average age of bulls in the beef breeds is 4·06 years $\pm$·04, while the average age of cows is 6·02$\pm$·05. For the dairy breeds the average age of the bulls is 3·69$\pm$·03 and of the cows 5·49$\pm$·05.

Horses.

(*a*) *Clydesdales.*—Work on the genetical construction of this breed, to which reference has been made in past reports, is being continued and kept up to date.

(*b*) *Inheritance of White Markings.*—Through the kindness of Sir John Gilmour, Lord Rector of the University, who placed the photographic records of the stud belonging to his father at the disposal of the Department, a study was made of the inheritance of white markings. It was found that the larger number of the progeny

have markings intermediate to their parents, about 10 per cent. have more markings than either parent, while a considerable proportion, about 30 per cent., have less markings. The inheritance of white markings therefore, appears to be dependent on several genetical factors. Amongst those animals with less markings than their parents there appeared to be a sex difference since there was a greater proportion of males than of females. It did not appear that the genetical white markings of any particular area were inherited independently of other white markings on the face or legs.

Pigs.

A committee was appointed to assist in the pig work of the Department and to advise the Animal Breeding Committee upon the conduct of the pig work. This Committee consists of practical pig breeders, one bacon curer and one member of the Animal Breeding Committee.

(*a*) *Pig Testing.*—The Pig Testing Scheme which was started in the late summer of 1928 has made such progress that during the whole year under review practically all the pig accommodation at the Department has had to be devoted to this purpose. During the first six months of the testing operations the information obtained from the tests was used as a criterion by which the final points concerning the scheme were determined, more especially those concerning the basis on which the awards were to be made. With the year's experience the scheme is now fully organised and is approaching the stage when it can be run along routine lines. It is proposed to publish the first report of the testing station at the beginning of 1930.

(*b*) *Genetical.*—Owing to the lack of accommodation other experimental work on pigs has been seriously hampered because of the difficulty of getting sows to conceive while housed under exceedingly bad conditions. Accordingly, not much progress has been made with matings designed to explore in greater detail than can be done at the Pig Testing Station, the factors which go to make the ideal type of bacon pig. Certain other work, however, has been continued such as the inheritance of colour and of specific characters such as rupture, " rose," etc.

(*c*) *Physiological.*—Some physiological work is at present in progress with litter groups in order to test out the effect of extract of pituitary gland upon growth.

(*d*) *Other Work.*—Data relating to fertility and factors affecting litter size have been considerably augmented both from the records of litters produced at the Department and (more especially) from the records of private breeders.

Since it is so difficult to collect data under the adverse conditions at present encountered at West Mains, the courtesy of private breeders in giving the full facts concerning their herds is very much appreciated. Some important data have been secured which deal

with the relative economy of live-weight gain at different weights and ages in different breeds and crosses.

Goats.

The new goat equipment has been in full working order during the past year and adequate records of yields have been taken for the first time since work on goats was started. Some physiological work has also been accomplished with a view to testing out various extracts which might have the effect of increasing sexual growth or of causing female goats to conceive at desired times of the year. The conclusions on this point are as yet indefinite. Much effort has been wasted combating goat sickness, a parasitical disease with which the pasture land round the Department is infested. Unless better means are obtained of combating this trouble, it is doubtful whether it would be advisable to continue keeping goats at West Mains.

Sheep.

During the past year the mechanism made possible by a grant from the Empire Marketing Board became operative. This grant was made in order to provide increased opportunities for a continued study of the biology of the fleece.

The programme of work has been arranged under two main headings :—

(1) A study of the physiology of wool growth carried out exclusively at the Department.

(2) Work of an extended practical nature where the material studied was flocks of sheep throughout the country.

(1) *Physiology of Wool Growth.*—Much of the work under this heading has necessarily been of a preliminary nature. It was soon realised that in Scotland fleece problems were of a specific nature. The majority of the sheep population consists of Blackfaces, a sheep with fleece characteristics peculiar to itself. For this reason many of the results already obtained by other research workers are not applicable to the case of the typical Scots sheep.

A preliminary examination of the fleece has been made upon animals kept in the Department, and the periodicity of the growth of kemp and wool in the fleece has been established. It has been shown that, irrespective of clipping, the kemp has a growth time roughly from February–March till October–November, and that in the intervening period it remains in the fleece as a dead fibre only. Wool on the other hand, shows a period of most active growth from July till March. During the early summer months a large number of these wool fibres are shed from the follicles and unless the fleece is clipped these fibres form a dense pelted mass well known to flock owners as the " rise." When in excess or when clipping has been delayed this " rise " becomes pressed outward from the skin surface by the growth of the remaining fibres, and forms the " cot " of the

fleece which is so detrimental from the manufacturer's point of view. The results so far obtained are by no means conclusive, and the study is being continued.

Influence of Thyroid.—Further investigations are being carried out with a view to determining the rôle the thyroid gland plays in the production of wool. This work must of necessity proceed slowly, and up to the present the results are inconclusive. It appears however, that the thyroid is one of an important chain of endocrine glands which directly influence the character of the fleece. In some of the animals from which thyroids have been removed the character of the wool grown since the operations has changed in a striking fashion. The exact nature of the changes is, however, not yet determined. This work is being carried out firstly in Blackfaces, where the nature of the changes can be more readily noted than in certain other breeds of sheep which have been used by other investigators abroad, and secondly, in animals whose wool is coloured.

Rejuvenation and Stimulation of Maturity.—An examination of the rejuvenation and other theories of Voronoff is being continued. He claims that the implantation of a gonad graft from an active mature ram into an aged ram will confer upon the latter certain characteristics of the former, resulting in a return to full reproductive activity. He claims further that grafting an immature male with a graft from a mature male will result in an increase in growth rate and quantity of wool produced. Up to the present, while there are indications that a temporary stimulus does follow the implantation of a graft, it appears that this is quickly neutralised by a subsequent slowing down of activity. This work must be continued for some time before the results obtained can be looked upon as final.

Colour-Inheritance.—In collaboration with Mr. J. A. F. Roberts, of Torridon, Leeds, certain studies of the inheritance of fleece colour in sheep have been carried out, brown-fleeced sheep acquired from Professor Cossar Ewart being the subject of examination. The results of these studies will form the subject of a publication which will shortly be issued.

Scrapie.—In conjunction with the Animal Diseases Research Association, Moredun, the Department has made a preliminary investigation of the mechanism of Scrapie transmission from ram to ewe. This work is essentially of a long range nature, and results cannot be obtained rapidly.

Induction of Oestrum.—Some work has been done with a view to stimulating artificial oestrum in the sheep at a time when normally the ewe is in the quiescent stage. Extracts of the maturity factor from the anterior lobe of the pituitary have been used, but the work is not yet complete.

Two cases exhibiting abnormalities of the reproductive system were investigated. The first case was that of a bovine free-martin exhibiting extreme modification in the male direction, and the second was that of a lamb twin, the genitalia of which were similar

to those found in the typical free-martin range. The second case is of interest because the occurrence of the free-martin condition in sheep has been regarded as very doubtful.

(2) *Applied Work.*—A large number of leading sheep breeders in Scotland have agreed to collaborate with the Department in an endeavour to determine the nature of the inheritance of kemp and black-spotting in the fleece. A method of analysis for kemp, etc., applicable to the Blackface fleece, and the assessment of a figure value, has been undertaken. Preliminary work was necessary to establish as nearly as possible an average value by count and weight for each of the three main classes of fleece fibres—wool, heterotype fibre and kemp. The proportions of these in a given fleece are determined and a value is put upon each according to their divergence from the mean. It is expected that the results of the investigation will show whether elimination of kemp from the fleece without prejudicing its other qualities is a possibility or not. Concurrently with this the influence of face colour and black-spotting in the ram upon his progeny is being examined, but it is still too soon to draw any definite conclusions from the available data. It is hoped, however, that this examination, when it has been completed, will afford much information of a very valuable nature to the practical breeder.

Rabbits.

An interesting study on the wool production of Angora rabbits leads to conclusions relating to the influence of various factors which it was thought might affect wool growth and wool yield. It was found that age does not appear to affect the annual wool production of bucks up to three years. In the does an increase in the weight of the wool was noted in the third year, but this may have been due to fibre coarsening. It was found that small rabbits produce a greater weight of wool per ounce of live weight than do larger individuals and therefore there is no correlation between live weight and wool yield. On extending this study to include the effect of season it was found that this exercised a profound influence, the heaviest production taking place in the months September to January inclusive and the lowest from March to July. An interesting correlation between the presence of "furnishings" and high yield was observed, it being found that individuals with pronounced ear tufts were the best yielders.

In association with this study the effects of special feeding were examined and it was discovered that the addition of three drops of cod liver oil to the daily diet resulted in an average wool increase of 13 per cent. The addition of various mineral salts, however, brought about no increased yield.

A study of the inheritance of furnishings and wool yield in the Angora showed that both the possession of furnishings and heavy production of wool are due to simple factors which are dominant to

the alternatives of lack of furnishings and low wool yield. It is suggested that there are also modifying factors controlling the exact amount of furnishings and the actual yield.

An examination of data collected from seventeen studs situated in Great Britain, Ireland, Guernsey and Canada has revealed some interesting facts relating to duration of pregnancy, size of litters, sex ratio and infertile coitus. This examination is not yet complete, but it has already reached a stage when some definite facts can be demonstrated. It is found that duration of pregnancy is affected by season, breed, age and litter size. It is most prolonged in May and shortest in November, the variation moving in a smooth curve between these two months. Breed also produces a significant effect upon the length of pregnancy and large litters are carried longer than are small litters. The age of the doe has some effect, the duration of pregnancy being slightly decreased between the first and second litters and thereafter lengthened.

It appears that litter size is affected to a considerable degree by latitude, rabbits in the south tending to have larger litters than those in the north. Season also exercises an important influence, the litters produced in the months March to August (inclusive) being the larger. It was found by comparing different breeds that the larger the breed the larger also was the litter. With the exception of the Chinchilla and Chinchilla crosses, it would appear that litter size increases between the first and second pregnancies of does and thereafter steadily decreases. In the case of Chinchilla and Chinchilla crosses the litters do not decrease until the third pregnancy.

The sex ratio problem was one of greater difficulty than the preceding one. The data were limited and definite conclusions cannot yet be drawn. It does appear, however, that the sex ratio is inherited in the rabbit and that there are variations associated with the season, the breed and the stud. It appears also that the sex ratio increases with successive pregnancies.

The question of infertile coitus is important from a practical point of view, for over all the records examined 46·8 per cent. of matings proved infertile. Close examination revealed that there was a seasonal variation, the months of April, May, June and July having the highest percentages of fertile matings. It appeared also that variations can be due to the locality of the stud, to the breed and also to the strain.

Avian Sex Physiology.—The provision of a new brick house designed to accommodate any type of small experimental animal has made the conditions of work much pleasanter for the workers in this section. The new house is presently devoted entirely to poultry and 200 fowls are maintained on the intensive system.

The implantation of male reproductive organs in females has been productive of some interesting results, the first of which is the assumption of definite male feathering until the first moult when

the male feathers were replaced by normal female plumage. The combs also were affected by the operation, the large upright comb typical of the male being developed.

The reproductive systems of the operated fowls were seriously affected and the birds were divided into three classes according to the manner of their reaction. In the first class the normal function of the ovary was not interfered with and a male comb was not present. In the second, the functions of the ovary were affected to a greater or lesser degree. The birds did not reach sexual maturity until much later than is normally the case and the eggs were long and narrow. In the third and final class the primary function of the ovary was completely inhibited.

From this investigation it was concluded that in the body of the individual there is a specific substance (or substances) essential for the proper development and function of the reproductive glands. This substance is limited in quantity and when both male and female gonads are present in the one individual the functioning of one of the two sex glands leaves an insufficiency for the other which is consequently prevented from attaining full functional activity.

Other studies in this section included the collection and examination of data relating to the thymus gland of the fowl. It was shown that the thymus of the male is more than twice the size of that of the female and that the successful implantation of the ovary in the male brought about a very great reduction in the size of the thymus.

The effects of thyroidectomy and thyroid feeding upon the Brown Leghorn were studied. It was found that these operations had a pronounced effect upon plumage characteristics. It was shown that in the male the characteristic plumage depends for its maintenance upon a certain level of thyroid activity. In the female, however, both gonad and thyroid play their part in plumage development.

The genetics of Plumage Colour in the Turkey, the O.E.G. Bantam and the Duck, all formed subjects of studies which are still being pursued. The genetics of spangling were also examined and results so far obtained show that, contrary to the findings of previous investigators, spangling is a recessive character and is not sex-linked.

Mammalian Sex Physiology.—The work on ovarian secretion was continued. It was found that metabolism in female rats is strongly influenced by the ovarian secretion, and that its level is correlated with the oestrous cycle. It is, however, not the oestrous hormone (Alpha hormone) which is responsible for the rise in metabolism occurring at the end of the oestrous cycle, and the existence of another hormone regulating metabolism is assumed. In experiments carried out in ovariotomised mice (which never come in heat) simple injections of the so-called oestrous hormone did not induce oestrum, but injection of this hormone combined with water-soluble extract brought this about.

It was found that the creation and maintenance of conditions of pregnancy are due to a hormone present in the corpus luteum of the cow. A simple and characteristic test reaction, mucification of the vaginal epithelium, has been elaborated which makes possible the further purification and study of this hormone to which the name " Beta " hormone has been given.

The endocrine function of the ovary is diphasic. It was found that both phases of ovarian secretion depended upon the secretory function of the anterior lobe of the pituitary. The latter contains two " Rho " factors and to their study the activities of this section have been principally directed. One of these (Rho 1) incites the secretion of oestrous hormone and ovulation ; the other induces the production of Beta hormone and in the absence of either the ovary is inactive.

In the male Rho 1 was found to activate the testicle and be responsible for its development. Rho 2 appears to have the opposite effect. Both these factors are found in the human placenta and from this material extracts have been prepared which contain them. With these extracts human diseases of endocrine origin were treated and the preliminary results appear to be encouraging.

H.

DAIRYING.

36. NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING.

During the past year further progress has been made with the scheme of work which the staff of the Institute has designed for studying the problems which are involved in the production and handling of milk, and its use, either immediately as a food stuff, or after conversion into one of the many products into which it may be changed.

It is for the better understanding of these problems that three papers have been published during the past year, one of which deals with the practical utility of milk recording. It is interesting to note that milk recording seems to have been put in practice more than a hundred years ago, yet to-day " only some 8·7 per cent. of the dairy cows in England and Wales are in officially recorded herds." The author, therefore, discusses some of the objections to the official method of testing which may be hindering progress and suggests other services which the societies might render in order to inspire more enthusiasm among the breeders of dairy cattle. The difficulty which has been found is only one more illustration of the slowness with which knowledge, even when it has obvious financial value, penetrates the general body of any society.

Two further papers are concerned ; one with the grading up of dairy shorthorns to pedigree standard ; the other, with a method of keeping accurate breeding records. These papers are not only valuable in themselves, but their perusal makes it abundantly clear that we have still much to learn concerning the true causes of the inheritance of milk qualities in a cow, and that a great deal still remains to be done before it will become possible to breed with such increased certainty of the result that much of the present necessity for discarding stock which does not come up to standard, even in herds in which the sires and dams are selected and recorded with care, may be avoided.

Two further papers deal with the variability of milk and fat throughout lactation periods. One of these records the weight of milk and the butter fat content of every milking of three cows throughout a lactation period, and the other the results obtained from a study of the quantity of milk and milk fat given by each cow in the dairy herd at the Institute on three consecutive days each month. The latter records extend over a period of five years. As the result of this work it has become possible to construct a mathematical formula which gives a measure of the deviations which are likely to occur and of the probable error of any average. By these means certain conclusions have been reached :—(1) that the three day monthly method of sampling and testing gives a very accurate measure of the fat content of the milk, and may be used as a means of checking the reliability of results taken at wider intervals, (2) that the six weekly method which is adopted by most milk record-

ing societies when compared with daily records may show differences in the fat percentage for the lactation period which vary from 0·10 per cent. to 0·30 per cent. These figures are based upon the study of 69 lactation periods, and, therefore, further work is being carried out in order to test the accuracy of the results which have been obtained.

This work has brought out certain other factors which are of very great interest, namely, that there may be very great variation in the average fat content of milk from cows of the same breed. Among the Shorthorns at the Institute it has varied from 2·99 per cent. to 4·60 per cent. The work has also shown that a high yield may be associated with any percentage of fat. In this connection other work at the Institute has demonstrated the variability in fat content which may be found to occur in the milk from the individual quarters of a cow.

These studies, when they are completed, will assist the milk recording societies to decide whether or not their present methods give them a fair measure of the fat from the cows in the herds. They also reveal the necessity for much more complete studies of the physiology of milk secretion, in order that the true causes of the variations in quality and quantity of milk which are known to occur may be discovered. Such studies as these and the variations in the suitability of different types of milk for the preparation of dairy products led the Board of the Institute to press for the appointment of a physiologist on its staff. This has now been accomplished.

Some years ago work was carried out at the Institute which demonstrated for the first time the serious fall in the calcium content of the blood which occurs in milk fever in cows. It is not often that such work leads to immediate practical results and the attempts to treat cows with milk fever in the Reading district with calcium salts were only partially successful, perhaps because the amount of salts which could be administered to the cow was limited. Since that time, however, Oscar Stinson, making use of a supply of calcium gluconate which was sent to him by Professor Greig and which can be inoculated in much larger quantities than was possible with the salts which were employed at Reading, appears to have met with a much greater degree of success.

Other papers which have been published during the past year have revealed the facts that the heating of milk for half an hour even at low temperatures affects rennet coagulation and the diffusibility of calcium salts. This work is of importance on the one hand, to those who are responsible for the preparation of dairy products, and on the other, to human nutrition, particularly in the young. A paper was, therefore, prepared which showed the present state of our knowledge on the relative values of fresh and pasteurised milk in human nutrition. The amount of such knowledge is extremely small and efforts have been made to promote further studies on the subject, since, if it were proved that it was a matter of importance

to the child that it should receive fresh milk, much more progress in the provision of such milk than is the case at present would follow. There is no doubt of the value of such result to the dairy farmer for it would enable him to obtain a much larger share of the price of milk than is the case at present, since the provision of such milk eliminates much of the very considerable costs which are involved in treating the greater part of our supplies before they reach the consumer. Moreover, if the nation were satisfied of the need for fresh milk it would greatly assist those who are interested in veterinary research and the elimination of the possibility of infectious disease from milk.

This report should not close without some mention of the extremely important work which is now being carried out at this Institute under the auspices of the Empire Marketing Board, and in collaboration with the Dominions Overseas. Such work will be reported upon as time goes on. In the meantime this and other work at the Institute have made it quite clear that a study of accurately controlled temperature and humidity conditions in ripening and storage of dairy products is essential.

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37. HANNAH DAIRY RESEARCH INSTITUTE, AYR.

I. General Development of the Institute.

During the year the plans for the Institute's new laboratories have been drafted, and it is hoped that they will be available for work early in the Spring of 1930. Meanwhile the Institute enters into possession of Kirkhill Farm, Auchincruive, near Ayr, which has, by arrangement with the West of Scotland Agricultural College, become the property of the Institute. Alterations and additions to the existing farm buildings are to be made in order to accommodate a herd of twenty milking cows and relative young stock; and a special metabolism house, in which digestibility trials with milking animals can be carried out, is to be erected. The laboratories will be located on a site adjacent to the farm buildings.

II. Work completed or in progress.

(*a*) *Tuberculosis in Dairy Cows.*—A survey of the extent of re-infection of cows in tuberculin-tested herds has been carried out by Mr. Fowler, who has also collected considerable data on the probable causes of such re-infection. A detailed report of this work is at present in preparation.

An experimental scheme of eradication has been initiated by the Institute in a small area in Ayrshire. The area extends to approximately nine square miles and comprises thirty typical dairy farms. The work undertaken by the Institute includes (i) free tuberculin-testing; (ii) supervision of the isolation of reactors and the rearing of young stock; and (iii) comparative tests of the infec-

tion of the milk at various stages of eradication. This work is being undertaken by Mr. L. Jordan, M.R.C.V.S., who is working in collaboration with the local veterinary practitioner. A special committee of the Medical Research Council is co-operating with the Institute in the general supervision of the scheme.

An examination has been made of existing data on the tuberculous infection of the milk supplies of Scottish cities, and a summary of the results has been published. These results show that existing data are unreliable owing to the variations in the technique used at each centre, and indicate the need for more extensive investigations to be carried out before any final conclusion may be reached on the present extent of infection.

(*b*) *Physiology of Milk Secretion.*—An investigation into the physico-chemical mechanism of calcium and phosphorus secretion has been completed, and the results published. Work is now being directed to two further problems—the origin of the milk proteins, and the synthesis and nutritional value of lactose. A review of certain scientific aspects of milk production has been published, and the summarised information contained in this review indicates the very wide field of investigation which still has to be tackled, particularly from the point of view of the fundamental processes underlying milk secretion.

(*c*) *Milk Fever.*—Investigations have been carried out jointly with Professors Dryerre and Greig of the Royal (Dick) Veterinary College, in order to extend the scope of the work previously carried out by Little and Wright and by Dryerre and Greig independently. The treatment of milk fever by means of calcium gluconate injections has been attempted, and the results indicate so far a high percentage of successes. This work is being continued. Attempts are also being made to produce the typical symptoms of milk fever by artificial means, and hence to obtain additional information on the causative factors concerned.

(*d*) *Surplus Milk and Milk Residues.*—At the request of the Scottish National Milk and Health Association the Institute undertook the editing and production of a report on this subject which had been prepared by Mr. Archibald MacNeilage, Junior. The report indicated the very considerable wastage of milk residues (separated milk and whey) at present existing in Scotland.

In order to supplement this report—particularly so far as the bacteriological and chemical aspects are concerned—Mr. Allen has been appointed to the staff of the Institute to survey the existing literature relating to the condensing and drying of milk. This will insure that future work will be carried out on a sound basis.

On the practical side, the Institute has obtained the co-operation of the Royal Technical College, Glasgow, and experiments are being carried out at the College on the mechanics of spray-drying.

38. DAIRY BACTERIOLOGY DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

During the year 1928–29 the work of the Division has been mainly advisory. Prior to January, 1928, there was no legislation in Northern Ireland dealing with the grading of milk, but at that time the Sale of Milk Act became operative.

This Act provides for the licensing of only one grade of milk, designated Grade A Tuberculin Tested, and producers are licensed by the Ministry of Home Affairs, the bacterial standard of this milk being the same as the corresponding grade of milk in England and Scotland. It is the function of the Division to stimulate the production of Grade A T.T. Milk and to advise prospective producers regarding suitability of premises, equipment, etc. ; also to examine bacteriologically all routine and surprise samples.

Owing to the numerous small farms in Northern Ireland, it is impossible for producers to avoid buying in cows from time to time and thus the problems connected with Tuberculin Testing and potency of tuberculin are of the utmost importance. In this connection investigations on a small scale have been made into the efficiency of the different methods of testing bovine animals for tuberculosis. The results obtained are in agreement with the findings of the Committee appointed by the Medical Research Council.

In addition to supervising the production of Grade A T.T. Milk the Division also affords advisory services to the creameries in Northern Ireland in connection with bacteriological problems and during the year preliminary experiments were carried out on the examination of starters with a view to determining whether contamination could be proved by bacteriological means before any obvious change was apparent in either the quality of the starter or the butter. This investigation is in progress.

I.

AGRICULTURAL ECONOMICS.

39. AGRICULTURAL ECONOMICS RESEARCH INSTITUTE, OXFORD UNIVERSITY.

(1) *Agricultural Costing.*—The study of the costs of production, through the accounts of some twenty farms of different types, has been continued, and results of interest to farmers have been published from time to time. Progress has been made in the collection of results of similar work carried on at provincial centres in the country, with a view to a national summary.

(2) *Agricultural Surveys.*—The technique of the survey method applied to the investigation of farm economics is being closely studied, and it is becoming clear that a wider application of this method of approach to farm management problems is capable of producing valuable results.

(*a*) *The Marketing of Agricultural Produce.*—A study of the production and distribution of milk in a Midland industrial county has been completed during the year, as a complement to that made last year in two rural counties in the west of England.

(*b*) *The Grazing Industry in the Midlands.*—A survey of the economics of beef production in the Midland grass belt has been completed.

(*c*) *The Mechanisation of Agriculture.*—Further progress has been made with the investigation of the extent to which the farmer is organising to increase the efficiency of labour and so reduce costs of production by the further application of machinery to farming processes.

(3) *The Economics of Sugar Beet.*—The examination of the economics of this crop has been continued, and a report on growers' experiences in the year 1927–28 has been published, together with a preliminary statement for the year 1928–29.

(4) *The Maintenance of Arable Farming.*—The study of an experiment in milk production on arable land in an eastern counties corn-growing and sheep-farming district has been completed and published. This venture is a valuable example of what may sometimes be accomplished by a breakaway from traditional local farming practice.

Other aspects of this question are being studied, in connection with the maintenance of arable farming in Berkshire, and an experiment with the reclamation of hill pastures in Wales.

(5) *The Incidence of the Agricultural Depression.*—With the co-operation of certain professional societies, an enquiry was made extending over England as to the state of farming, as evidenced by the frequency of notices to quit and requests for the reduction of rent. The results, which show the impossibility of any generalisations of prosperity or adversity, give certain indications of these conditions as regards localities and types of farming.

(6) *The History of Land Reclamation.*—Materials in private ownership concerning the stages in the reclamation of Exmoor Forest for agricultural purposes in the early part of the nineteenth century having been made available, an account of this work has been prepared as a contribution to economic history.

(7) *The Law of Diminishing Returns.*—A study of the operation of this law in agriculture has been completed and will be published in due course.

(8) *Agricultural Economic Research within the Empire.*—Considerable progress has been made in establishing connections with Agricultural Economic Research Departments within the Empire and in the study of the work in progress in them. This work is carried out with the aid of a grant from the Empire Marketing Board, and the Research Officer in charge also acts in an advisory capacity to the Economics Research Branch of that body.

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40. FARM ECONOMICS, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

The work of Agricultural Economics Investigation in Scotland is co-ordinated in the Department of Agriculture for Scotland and the three Agricultural Colleges.

The Headquarters' work consists of an analysis of the returns which are received on June 4th each year from persons occupying one acre or more of land. For a given year, the holdings are grouped according to the scale and type of organisation as revealed by the utilisation of land and the numbers of the different types of livestock carried.

The first step in the analysis is the deletion of holdings which play no part in agricultural production. Examples of these would be private gardens, butchers' accommodation, etc. In most cases the acreage involved is small, but the number of holdings thus excluded is quite appreciable. Attention next centres on the smallholdings, and it has been possible to define two groups, those occupied by persons who describe themselves as engaged in some non-agricultural pursuit, and those describing themselves as farmers. The legal definition of a smallholding is generally but not strictly adhered to, and often a natural cleavage has been found to occur between the larger farms and the smallholdings. Whatever the area under consideration, it is found that with certain exceptions, the remaining farms conform to one, or at most a few distinct types. The exceptions from the chief type are first segregated, and then some factor is sought on which a classification of the remaining farms showing similarity of production can be based.

In the Border counties, the first area studied, a suitable basis of classification was found in the rent per acre of land. The groups

taken were 0s. to 7s. per acre, 7s. to 12s., 12s. to 17s., and so on. A statistical classification of farms according to type is regarded as essential to the correct interpretation of accounting and other data collected.

A basis is here provided for the selection of suitable farms from which accounts can be obtained, and if the sample of farms taken is sufficiently representative, these accounts will permit of the interpretation of the financial position of the whole group of farms, and, in due course, of the industry as a whole.

The preliminary classification will, moreover, form a valuable groundwork for other investigations devoted to special points. For example, at the present time an investigation is in progress into the Marketing of Livestock in Scotland under grants from the Empire Marketing Board, and a modified form of statistical analysis is being resorted to in order to throw some light on to the production side of the marketing problem in the various areas.

J.

PRESERVATION
and
TRANSPORT.

41. DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND UNIVERSITY OF CAMBRIDGE.

Low Temperature Research Station.*

Work in progress during the year can be classified roughly under the following headings :—

The theory of the freezing of tissues as a physical process. The effect of cold upon the chemical constitution of muscle.

The factors which determine the "bloom" of meat, and a survey of the conditions which obtain in the transport of carcases.

The effect of storage upon fat.

The special problems involved in the transport of pork and bacon.

The chemical changes in stored fruit, especially of the apple, pear and citrus fruits.

The growth of moulds and the diseases of fruits in storage.

The heat produced by apples.

The influence of foodstuffs on the corrosion of cans.

The rate of loss of water by eggs in storage.

These subjects are dealt with in detail in the Annual Report for 1928–29 of the Food Investigation Board (H.M. Stationery Office).

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42. CAMPDEN FRUIT AND VEGETABLE PRESERVATION RESEARCH STATION UNIVERSITY OF BRISTOL.

During the last year this sub-station has continued its work in connection with the problems of fruit and vegetable preservation in this country. The principal subjects of investigation have been concerned with the rapidly developing canning industry, and the research has been carried out largely with a view to assisting growers and commercial canning firms in improving the quality of English canned fruit and vegetables.

(1) *Variety Trials. Strawberries.*—The development of the fruit canning industry during the past few years has shown itself very markedly in an increased demand for canned strawberries, and as there is a shortage of the better known canning varieties, it was considered advisable to carry out canning trials on the chief varieties of strawberries available in this country. In a number of cases the same variety was obtained from several parts of the country to

* Report included by courtesy of the Department of Scientific and Industrial Research.

determine the possible effect of soil, climatic conditions, and capacity to withstand long journeys by rail. To get fair average conditions the varieties will be canned during three or four seasons. Up to the present, the tests have been carried out over two seasons, and from the results obtained the following varieties appear very suitable for canning: Oberschlesien; Sir Joseph Paxton; Stirling Castle; Stirlingworth; Tardive de Leopold; and Lord Grenfell.

Plums.—In addition to the two commonest canning varieties of plums, namely, Pershore and Victoria, tests have been carried out on other well-known varieties. The following appear to be very suitable for canning: Purple Pershore; Blaisdon Red; Magnum Bonum: and Early Prolific. Czars, Evesham Wonders, and Orleans had a good flavour, but the skins were poor in colour.

Raspberries.—Raspberry variety trials have been carried out for several seasons and over thirty varieties have been canned. Arrangements have been made to test a large number of varieties grown at the Royal Horticultural Society's Gardens at Wisley. Some thirteen varieties were tested this year, and these tests will be repeated next season.

Peas.—In addition to the commoner varieties of English peas, seven varieties of peas used extensively in America for canning were grown in the Research Station garden, and were subsequently canned. All these gave good results, and in two cases, namely, Perfection and Horsford Market Garden, the product was exceptionally fine.

(2) *Use of Vacuum Closing Machine in Canning Fruit.*—A machine for closing cans under vacuum is on loan to the Research Station, and extensive tests have been carried out on all English fruits. Certain of these tests should show whether subsequent corrosion is less in cans sealed under vacuum, but experiments in the colour, flavour, and sterilisation times required, have been carried out to compare this process with the normal heat exhaust.

(3) *Corrosion Tests.*—Apart from destruction of the contents of cans through bacteriological action due to insufficient sterilisation or faulty cans, the chief cause of spoilage in canned fruit is corrosion of the tinplate by the fruit acids. This may be localised, and cause perforation of the tinplate, or it may be spread over a larger area causing the evolution of hydrogen which eventually leads to doming of the cans. Spoilage of cans from these two causes is not as serious in this country as it is in America, and this may be due partly to the cooler storage conditions met with in England. The development of export trade to the tropics has, however, made this temperature factor of considerable importance, and it is therefore essential to determine the nature of the corrosive action, and to establish a practical method of reducing this spoilage to a minimum. From a practical aspect the principal points to consider are the type of tinplate and lacquer used, the nature of the exhaust process, and possibly the time and temperature of sterilisation. The theoretical factors of importance are the presence of oxygen in

the cans which has not been completely removed from the intercellular spaces of the fruit, the acidity and pH of the juice, the inhibiting action of sugar syrups, and the depolarising action of the anthocyanin pigments.

It is not possible in a single year to study all the features of the problem, but an attempt was made during the past year to investigate several of the factors mentioned above.

A large number of cans of the various fruits were processed in the ordinary way, and these will be compared for development of signs of chemical spoilage with cans sealed by the vacuum process. This should make it possible to judge whether vacuum closing removes oxygen from the cells of the fruit more efficiently than the heat exhaust method.

In the case of strawberries and loganberries, tests were made in which the air was removed under vacuum, and the vacuum released several times with an inert gas to remove the last traces of oxygen occluded in the fruit. The cans were then closed under vacuum. If oxygen is an important factor in corrosion, these tests should show a marked improvement as regards chemical spoilage when compared with cans processed in the normal manner. The exclusion of oxygen may also have an appreciable effect on the colour of the canned fruit.

To determine the effect of the natural colouring matters the fruit juices were extracted, filtered, and adjusted to the acidity normally present in the particular canned fruit. By adding these juices boiling to the cans, and sealing immediately, air was excluded, and the effect of the colouring matter and acidity isolated for subsequent study. By repeating these tests with cane and invert sugar syrups the inhibiting action of the latter is being examined.

(4) *Syrup Strengths.*—By weighing in the contents of each can accurately, the relationship between the original solid and liquid contents and the final density of the syrup is being determined for each fruit, using a large range of syrup strengths. The accurate packing of all fruits canned in a range of syrups should assist in the standardisation of syrup strengths used in fruit canneries in this country.

(5) *Sterilisation.*—It is sometimes advisable to sterilise soft or overripe fruit for a shorter period than firm ripe fruit, and it is of importance to know the minimum sterilisation periods generally required for the various fruits. This has been investigated both after heat exhaust and after vacuum closing.

Vegetables may be sterilised in the home at 100° C. by the addition of lemon juice or citric acid to the covering liquid. The minimum quantity of acid required, and the pH conditions involved are being ascertained.

(6) *Fruit Juices, etc.*—Sweetened fruit juices have been prepared and other methods of utilising soft or overripe fruit have been studied. Canned fruit purees for flavouring purposes have given quite satisfactory products. Fruit juices have also been concentrated under

vacuum to give products of sufficient concentration for use in soda fountains, chocolate centres, ice-creams, etc.

(7) *Dessert Fruits in Brandy.*—Following an enquiry received last year, strawberries were preserved in a syrup containing brandy. This season raspberries, loganberries, blackcurrants, and cherries have been treated in a like manner.

(8) *Vegetables.*—The preservation of vegetables in this country has increased very rapidly during the past two years, the greatest development having taken place in the canning of peas.

This sub-station has been engaged for several years on the problems concerning pea canning, and in addition to testing some forty varieties, has carried out a large number of experiments on the various processes involved in the canning of this vegetable. The recent prohibition of the use of copper sulphate necessitated the discovery of some alternative method of preserving a green colour in canned vegetables, and much of the research work has been concerned with this particular problem. The experiments were carried out on peas, and the two methods most likely to yield satisfactory results were found to be: (*a*) the stabilisation of the naturally occurring chlorophyll by means of control of the conditions of acidity inside the can; and (*b*) the use of a harmless green food colouring matter which would be evenly absorbed by the peas.

The conditions of hydrogen-ion concentration required to render the chlorophyll stable at the temperature employed during sterilisation were investigated very thoroughly, and a large number of suitable alkaline buffers were tested. It was found to be quite possible to preserve the natural green colour, but the increased alkalinity of the medium softened the peas, rendered sterilisation more difficult, and spoiled the flavour. Even under the most satisfactory conditions, however, there was a gradual loss of colour on storage.

The experiments on the addition of a food colouring matter yielded much more satisfactory results, and although the ideal product has not yet been obtained, the prospects of developing along these lines are very promising. As this work is still actively in progress, the results have not yet been published in the form of a paper.

(9) *Lacquer Tests. Fruits.*—The tests on the protective action of various types of lacquer which were started in 1927 have been completed this year. Very definite and satisfactory results have been obtained as a result of these experiments. Sets of cans were opened after various periods of storage, and the appearance and colour of the fruit and syrup were noted. The acidity, hydrogen-ion concentration, and tin content were determined on every sample, and these were correlated with the appearance of the fruit, and with corrosion of the tinplate. Double lacquered cans (particularly in the case of red and purple fruits) showed much less sign of corrosion and contained less tin in solution or suspension than single lacquered cans. The appearance of the contents in the former type of can was

also much superior. It is hoped that the results of these tests will be published in the near future.

Vegetables.—The blackening of the inside of cans due to the breakdown of sulphur compounds in canned peas, beans, etc., has long been a source of complaint. Special types of lacquer intended to overcome this difficulty have been tested out at the Research Station, and in one case very satisfactory results were obtained. This lacquer is now being tested out on a commercial scale in the canning of peas.

The extensive tests on varieties and on corrosion of tinplate necessitated packing several thousand cans this season, and these cans are being stored in a constant temperature room at 72° F.

In addition to accelerating chemical action inside the can, and thus enabling results to be obtained within a reasonable time, this warm temperature storage should be of value to those interested in canning for export to warmer climates.

K.

AGRICULTURAL ENGINEERING.

43. INSTITUTE FOR RESEARCH IN AGRICULTURAL ENGINEERING, OXFORD UNIVERSITY.

I. Research.

(*a*) *Dehydration of Crops and Products.*—(1) *Crop Drying.*—This question continues to be watched by the Institute. The use of fuel oil and paraffin for heating the air has been superseded by coke. A portable vertical coke heater has been designed which can be used effectively with all types of dryers. A conveyor belt dryer has been tested during the past season and has been found to possess definite advantages over the stack and tray methods. This dryer has lately been used to dry young grass, the special feeding value of which has recently received considerable attention. The effect of drying temperature on crude protein content has been investigated and it has been found that where a dryer of the conveyor type is employed, temperatures up to 300° F. have no harmful effect.

Small scale experiments have been carried out in the drying of hops with a view to shortening the time ordinarily required for drying. A good sample was obtained, with a drying period of five hours, which is half the normal period.

In view of the surplus potatoes at certain seasons, some experiments in the drying of potatoes have been carried out in conjunction with the beet factory at Eynsham. Over 100 tons were dried. A good white sample was obtained, which on analysis was found to compare favourably, for use as a feeding stuff, with barley meal.

Experiments have also been made in the drying of brewers' grains and malted barley, and have given good results.

(2) *Desiccation of Sugar Beet.*—A report on the process for the desiccation of sugar beet was issued by the Institute in August, 1929, as Bulletin No. 4. This was compiled with the object of completing previous reports on the Institute's experimental work by an account of the process under the practical test of commercial application.

(3) *Grain Drying.*—The portable grain dryer, referred to in last year's report, was reconstructed and provided with a coke heater, in place of the oil burners used last year. It consumes under 28 lbs. of coke per ton of grain treated.

(4) *Other Work in Drying.*—The dryer for flax seed supplied to the Flax Factory at Yeovil was successfully used to dry the whole of last season's seed.

(*b*) *Sugar Beet Research.—Colloids in the Juices.*—Further work has been done in regard to the colloidal constituents of sugar beet, especially in connection with their removal from juices of high density. In order to remove the colloids their flocculation must be brought about. In viscid liquids it is not possible to produce this flocculation by the method of neutralising the electrical charge of the colloidal particles. If this failing to flocculate is, as seems

highly probable, due to their association with water, there would seem to be an indication that if the particles can by some method be dehydrated, the flocculation and eventual removal of the colloids should be practicable. This has been found to be the case and details of the method will be published shortly.

(*c*) *Drainage.*—The Institute has kept in close touch with developments in mole drainage. A member of the staff assisted at the Mole Drainage Demonstration held by the Ministry of Agriculture at Barnstaple in November and at Studley College in December, 1928.

A memorandum is in course of preparation setting out the present position and indicating the relative costs of different methods of operation and their advantages and disadvantages. In view of the recently-awakened interest in France and Germany in this method, a considerable amount of foreign literature is being studied.

(*d*) *Cultivation.*—Owing to the sale of the University Farm the trials there laid down in 1927 were discontinued.

At Pin Farm, near Oxford, which, as stated in last year's report has been leased for the use of the Institute, experimental crops of sugar beet and linseed have been grown. These were sown with the tractor drill designed and constructed by the Institute.

(*e*) *Sub-soiling.*—The few remaining plots in Essex which have not been affected by disturbing influences have been harvested. On one of the fields, which was re-sub-soiled in the spring of 1928, a marked increase of crop (potato) was noticeable on the newly sub-soiled land.

(*f*) *Electricity on Farms.*—The report on the investigation conducted on the use of electricity on farms in the Chester area was issued in June last. The actual report was supplemented by some general considerations affecting the supply and price of electricity in the Ayrshire district rural areas.

(*g*) *Windmills for the Generation of Electricity.*—The Institute's report (Bulletin No. 1, 1926) on this subject has been out of print for some months. Many enquiries on the subject continue to be received. As new machines have been developed since the Harpenden tests were completed, arrangements have been made to test *in situ* some of the latest types. The results of these tests will be published together with certain parts of the original report and some information from foreign sources.

II. Testing.

(*a*) *Ministry's Testing Scheme.*—Tests under this scheme completed or in progress during the year include :—

Test completed.

(1) Two tractors developing 40 h.p. at the belt and 23 h.p. at the drawbar. The tests followed the lines laid down at Nebraska (U.S.A.) and the dynamometer car referred to in last year's report was used.

(2) A 6 h.p. Oil Engine.

(3) Milking Machine Tests (*).

4) Milking Machine Mechanical Tests (*).

(5) Fuel Oil Burner.

(6) Milk Cooler Mechanical Tests (*).

(7) Manure Distributor (Confidential Report).

Tests in Progress.

(1) Fuel Oil Carburettor.

(2) Milk Emulsifier Mechanical Tests (*).

(3) Mowing Machine.

(*b*) *Royal Agricultural Society of England.*—Following the procedure inaugurated last year twelve implements entered as "new implements" for the Society's Silver Medal at the Royal Show were tested at the Institute or inspected by the staff and reports drawn up on each.

(*c*) *Trials of Implements.*—(1) *The Combine Harvester-Thresher and the Grain Dryer.*—A report on the Combine Harvester trials of last year has been published (Bulletin No. 3). This report stated that :—The combine is a practical means of harvesting grain in this country. The climate is not a bar to its use and the adoption should be seriously considered by large grain growers. It added that where straw was sold and was an important part of the crop, the use of the combine could not be recommended ; also that means of drying the grain must be regarded as a necessary part of the combine harvesting plant. In order to follow up last year's trials and to get further information and data as to the advantages and disadvantages of the method, and incidentally to give farmers the opportunity of judging for themselves, trials of three different makes of combine harvesters were arranged in Lincolnshire, Hampshire and Wiltshire. Altogether 140 acres of wheat, barley and oats were cut and threshed during these trials, which were attended by a large number of farmers. The portable grain dryer was taken to each centre ; owing to the very dry weather prevailing it was not necessary to dry any of the wheat and oats, and the dryer was used on some of the barley only.

During the trials tests were made of the windrow method of using the combine harvester. This method has been thought to be especially suitable to English conditions. Using this method it was found possible to harvest a crop so weedy as to be impossible to harvest by direct combining ; but for clean and evenly ripened crops the advantages do not seem to outweigh the extra cost.

(2) *Demonstration of Tractors.*—In connection with a course for County Educational Staffs a public demonstration of tractors and

* Other tests carried out by the National Institute for Research in Dairying, Reading.

cultivating implements was held on 18th October, at Pin Farm, South Hinksey. Seven different tractors and two smaller motor cultivators were seen at work. The implements included various ploughs, a disc harrow and a cultivator. There was a large attendance.

(*d*) *Experimental Machines.*—A Sugar Beet lifter is being constructed by the Institute. The idea is to top, lift and elevate the beet at one operation into a vehicle drawn along the row. The construction of such a machine presents many difficulties, which can only be overcome experimentally. It is intended to give the machine preliminary trials shortly.

A combination tractor drill and hoe has been constructed, with which a small acreage of sugar beet and linseed have been planted and cultivated. In the light of the experience gained this machine is being reconstructed, and it is hoped to produce a machine which will be suitable for use by the small farmer.

III. Education.

County Agricultural Education Staffs.—A course of instruction in agricultural engineering for members of County Agricultural Education Staffs was held from the 15th to 27th October. The general plan adopted was to give lectures during the mornings followed in the afternoon by practical field and machine shopwork. A large number of tractors and implements of special interest were used in practical demonstration and the course also included such subjects as electricity, steam and internal combustion engines, drainage and sub-soiling.

The number attending the course was thirteen.

IV. Advisory.

A considerable number of enquiries continue to be received on agricultural implements and on questions of agricultural engineering generally.

V. General.

World Tractor Trials.—The Royal Agricultural Society of England has issued details of trials of agricultural tractors and other power cultivating machines, which it is proposed to hold in 1930. The Institute will co-operate with the Society in these trials, which will consist of two parts; tests of a scientific and practical nature not open to the public, and a public demonstration. The trials are open to machines manufactured in any part of the world, and there are no restrictions as to weight or horse power.

II.

LOCAL INVESTIGATIONS at ADVISORY CENTRES.

L.

CHEMISTRY.

44. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

The effect of manures on the mineral content of the herbage of pastures cut at monthly intervals.—Three plots (1) Control ; (2) Phosphate and Potash ; (3) Nitrogen, Phosphate and Potash were laid out at seven centres ranging in altitude from sea-level to over 1,000 feet. Broadly speaking the influence of the manures is more pronounced on upland than lowland pastures. The application of phosphates and potash increases the percentage of nitrogen and phosphoric acid, whereas the addition of nitrogenous manures (Sulphate of Ammonia and Nitrate of Soda) in the majority of cases depresses the phosphoric acid content of the produce.

Influence of Maturity on the chemical composition of eleven species and strains of grasses.—The grasses were first cut on April 30th, 1928, and subsequent to this at monthly intervals up to July 30th, 1928. On August 1st, the plots were completely cleared of all growth, i.e., portions sampled and not sampled. From the August cut the growth went on through the autumn and winter and monthly cuts were taken until April, 1929. The first four cuts April-July show all the changes in composition generally associated with maturity such as rise in fibre and a fall in protein and silica free ash. The latter is reflected in the majority though not in all by the fall in lime and phosphoric acid. The monthly cuts taken after what may be looked upon as the aftermath (September 3rd cut) are much more irregular in their variation due largely to the difference in habit of growth.

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45. BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

The principal task of the Agricultural Chemistry Department at Bangor is the Soil Survey of Wales. Methods of mapping are still the subject of discussion, but so far as Wales is concerned the work is proceeding on lines which ensure that all essential data are recorded and mapped. The field work is being executed by Messrs. D. O. Hughes, M.Sc., and Brynmor Jones, M.Sc. Over 60,000 acres have been surveyed during the past season. It is hoped that a greater rate of progress will be attained now that methods are better elaborated. The principal contribution on the research side is a new method for determining organic carbon in soils. This appeared as a joint paper by G. W. Robinson, W. McLean and Rice Williams in the Journal of Agricultural Science. The method is based on the well-known Kjeldahl procedure and is suitable for routine work. Nitrogen may also be determined as part of the operation Mr. Rice Williams has published a further paper on the use of acetic acid as an extracting

agent for the determination of exchangeable bases in soils. In it he deals with magnesium, potassium and total bases. He is at present engaged on a method for exchangeable sodium. Mr. McLean has been working on the carbon-nitrogen ratio of soils and a paper is now ready for the press.

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46. BRISTOL UNIVERSITY.

1.—Grass Land.

(*a*) *Nutritive Value of Grass.*—The nutritive value of pasture grass under various systems of management and manurial treatment is being studied.

(*b*) *Eradication of Black Grass* (*Alopecurus Agrestis*).—These investigations have now been completed and a report will appear in the Journal of the Ministry during the early part of 1930.

(*c*) *Variety Trials of Rye Grass and Cocksfoot.*—These investigations into the behaviour of certain varieties of rye grass and cocksfoot under intensive grazing are being continued.

(*d*) *Pasture Research Committee's Experiments.*—Two centres of this national scheme of experiments have been established in the Bristol Province.

(*e*) *Manurial Trials.*—Further investigations into the effects of certain phosphatic and potassic fertilisers on grass land are being conducted.

2.—Arable Land.

(*a*) *Persistency of Strains of Red Clover.*—These experiments are being continued.

(*b*) *Sugar Beet.*—The investigations in connection with the storage and analysis of sugar beet have now been completed and a full report will appear in the Journal of the Ministry early in 1930.

(*c*) *Land Drainage.*—In conjunction with the Land Drainage Authorities, experiments are being made in order to trace the effect of mole drainage on the texture of certain heavy soils.

3.—Dairying.

The investigation into the " Effect of Different Balanced Rations on the Yield and Composition of Milk from Dairy Cows," which was being conducted in collaboration with the Adviser in Dairy Bacteriology has now been completed and a bulletin on the subject has been published.

4.—General.

(*a*) *Mole Destruction.*—At the request of the Ministry a set of experiments was commenced in 1928 in order to compare the efficiency of Red Squill (*Scilla maritima*), Cyanogas and Horo-gas in ridding

badly infested areas of land of moles. These experiments are being continued.

(*b*) *Feeding Stuffs.*—Attempts are being made to solve the cause of death or illness of fairly large numbers of stock, where the trouble is said to have originated from the foodstuffs fed.

(*c*) *Hops.*—Large consignments of hops are being refused by buyers on account of the supposed contamination by arsenic of the hops. This problem is being investigated.

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47. CAMBRIDGE UNIVERSITY.

(1) *Acid-Treatment of Sugar Beet Seed.*—In collaboration with Dr. R. M. Woodman, further investigations have been carried out this season on the effect of Sulphuric Acid Treatment on the Germination of Sugar Beet Seed under varying soil and climatic conditions. The data obtained are at present undergoing statistical analysis and it is hoped to publish a report very shortly.

(2) *Ministry's Sugar Beet Demonstration Schemes,* 1928 *and* 1929. —The Advisory Chemist supervised the sampling and weighing of the plots arranged under the 1928 Scheme in the counties of Huntingdonshire and the Isle of Ely and arranged further plots under the 1929 Scheme in the same two counties.

(3) The Advisory Chemist has assisted in the collection of data at two of the five centres in the Province which are carrying out small scale trials on the Intensive Manuring of Grassland under the aegis of the Cambridge Provincial Conference.

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48. HARPER ADAMS AGRICULTURAL COLLEGE.

Experiments in the Cultivation of the Sugar Beet Crop in the West Midlands during 1927 *and* 1928.—These experiments were designed to show the effect of variations in the spacing of Sugar Beet plants on the yield per acre. The results of the 1927 experiments indicated that :—

(1) The greatest expectation of yield is to be obtained when the rows are close together.

(2) There is no marked effect on yield by varying the distance between the plants in the row (up to 10 inches).

(3) The returns showed a distinct advantage in favour of growing on the ridge compared with growing on the flat.

The experimental results of 1928 corroborated those of 1927 and afforded further information, viz. :—

That in conjunction with a crop of 13 tons of washed beet a crop of 20 tons of fresh tops and 1 ton of crowns may be obtained.

Changes occurring during the Clamping of Sugar Beet.—Sugar Beet clamped in October, 1928, was sampled periodically up to the end of January, 1929.

(1) Maximum moisture loss took place early and contributed to an increase in percentage of Sucrose and Dry Matter.

(2) Further change did not take place until the middle of December when the reducing sugars began to increase (from 0.2 per cent. to 0·35 per cent.). These changes were accompanied by loss of Sucrose and Dry Matter.

Critical Data on the Effect of Soil Acidity on the Growth of the Sugar Beet Crop.—Data collected in 1927 and 1928 respectively show the critical pH values of 5.2 and 5.3, below which failure of the crop took place.

Estimation of Tare and Sugar Content in Commercial Sugar Beet Practice.—From experiments carried out at the local factory, the following conclusions were derived :—

(1) *Total Dirt Tare.*—In most cases the tare as determined by the average of ten samples per wagon was higher than that of the official samples. Variations in dirt tare of samples from one consignment were very great.

(2) *Sugar Content.*—The official sample seemed, on the whole, to represent the average for each wagon.

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49. LEEDS UNIVERSITY.

(1) A study is being made of the relation between the size of Sugar Beet and the content of Sugar and Dry Matter by the analysis of a large number of individual roots. Results hitherto obtained indicate that the larger the roots the smaller is the percentage of Sugar. The work is being repeated during the present season.

(2) The mode of formation of podsols and of iron pan has been studied and continues to receive attention. A further explanation of pan formation has been advanced, namely, that when soil organic acids dissolve iron compounds the iron enters the electronegative portion of the molecule. An insoluble isomer, a basic salt, is later formed and accumulates in a zone which ultimately forms a pan. Recent work has shown that Aluminium compounds do not necessarily take part in pan formation.

(3) In co-operation with the Economist a preliminary investigation is being made into the factors governing the successful growing of Sugar Beet and Flax. It appears that the soil conditions favourable for Beet are also the most favourable for Flax.

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50. MANCHESTER UNIVERSITY.

The study has been continued of the main soil groups in the province with a view to classification on the basis of type and agriculture practised ; determination of pH and " lime-requirement " were always made in order to assess the need for lime in the area and those figures were usually supported by observations on loss-on-ignition and exchangeable calcium.

The investigations on *Heterodera schachtii* dealt with the relationships between degree of infestation, crop yield and lime status of the soil. The intensity of the disease was much decreased during the year. No significant correlation was found between the yield of potatoes and lime status.

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51. MIDLAND AGRICULTURAL COLLEGE.

(*a*) *Day to Day Variation in the Composition of Milk.*—Since March, 1928, daily samples of the milk of a herd of 30 cows have been analysed for Fat and Solids not Fat. The object of this work is to ascertain the extent of the variation in the percentages of these two constituents from one day to the first, second or third day after. This investigation is proceeding.

(*b*) *Fishy Taint in Milk.*—A preliminary investigation into the cause of a fishy taint in milk produced on certain farms last winter during the feeding of a ration containing molassed sugar beet pulp has been carried out. The substance causing the taint has been isolated from the milk, and a technique for its estimation worked out. In co-operation with the National Institute for Research in Dairying and the Harper Adams Agricultural College, schemes for feeding trials and for further research have been worked out. It is planned to carry out this work during the coming winter.

(*c*) *Trials of Varieties of Soya Beans.*—Plots of four varieties of hardy soya beans have been grown for seed this past summer. The harvest results were not available at the time of writing this report.

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52. NEWCASTLE : ARMSTRONG COLLEGE.

1. *The Loss of Sheep by Phosphorus Poisoning on Artillery Ranges.* —Investigation completed, and reported in the Journal of the Royal Army Veterinary Corps, Vol. I, November, 1929.

2. *The Reaction Changes Brought About on North Field, Paradise, Cockle Park, Northumberland, by Draining and Manuring.*—Experimental work completed. Results undergoing statistical examination.

3. *The Composition of Pig Swill Produced in the Hotels, Restaurants and Cafés of Newcastle-upon-Tyne and Sunderland.*—Investigation proceeding.

4. *A Lime-requirement Study of Some of the More Important North of England Soil Types.*—Investigation proceeding.

5. *The Nitrification and Nitrogen Fixing Capacity of Soil from the Tree Field Plots at Cockle Park, and from Certain Experimental Plots at Houghall, Durham.*—Investigation proceeding.

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53. OXFORD UNIVERSITY.

Soil Survey.—A map of the soil regions occurring in Northamptonshire has been prepared as a preliminary to an intensive soil survey of the county in the near future. The work is not an end in itself since many soil types have been ignored as too small to fall in with a regional scheme.

Oats.—There appear to be differences in the amount of fibre, soluble materials, and ash constituents in oats which are resistant and oats which are susceptible to Frit Fly attack. Since the ash constituents of cereals may be modified by manuring, it may be possible to assist resistance by suitable manures.

Beet.—The growth increments and sugar accumulation have been studied for twelve varieties of beet during the period September 1st to October 18th, 1928. This is the first year of the experiment, and as the season was a bad one for the differentiation of the special properties of the varieties, the data are being kept for use in future experiments.

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54. READING UNIVERSITY.

Manuring of Malting Barley.—A field investigation of the effects of the three chief plant nutrients (five plots) was conducted for the third successive year. The trial was run in quadruplicate. Weights of grain have been taken and samples have been taken for laboratory examination.

Liming.—Experiments have been laid down in the field on grassland and observations are being made on the rate of penetration of the lime into the soil, and on the depth distribution at intervals.

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55. SEALE HAYNE AGRICULTURAL COLLEGE.

(1) *Liming Trial.*—A twelve plot experiment was started in 1927 at Carn Brae on newly broken-in woodland. The yield of oats in 1927 and 1928 showed an increase of about 30 per cent. with the full " lime requirement." This year a crop of " seeds hay " was cut but no crop of value was obtained on the " untreated " plots.

(2) *Lucerne.*—The difficulties in obtaining a stand of lucerne on the shale soils of Devon and Cornwall appear to be mainly cultural. Manurial trials are being conducted to determine how far potash might be beneficial on such soils for this crop.

(3) *Toxic Effect of Sea Sand.*—This effect has been obtained by the use of calcium carbonate alone at rates of over 15 tons per acre. The crops affected are oats, potatoes and certain bulbs (narcissus), Nitrification appears to be very little affected under these conditions.

(4) *Patch Disease in Strawberries.*—The prevalence of this disease in Devon and Cornwall is confined to one or two main soil types, the shale and " killa " areas. Comparative studies of good and bad plots suggest that available potash is one important factor. An experiment has been started to ascertain the effect of fairly heavy dressings of this fertiliser.

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56. WYE : SOUTH EASTERN AGRICULTURAL COLLEGE.

Laboratory investigations connected with the fungicidal properties of various forms and compounds of sulphur have been continued and a number of biological tests with those substances have been carried out in collaboration with the Mycological Department. Wetted sulphur, colloidal sulphur, dry-mix lime sulphur and certain polysulphides have been examined. Some preliminary work has been done upon the influence of " spreaders " upon the fungicidal action of sulphur sprays.

Field spraying trials against apple-scab, also in collaboration with the Mycological Department, have been carried out at two centres. At the first centre, in the College plantations, where spraying trials with Bordeaux mixtures have been in operation for the past three years, a comparison was made between lime sulphur and Bordeaux mixture. At the other centre, in the County, three commercial varieties—Worcester Pearmain, Allington Pippin, and Newton Wonder, were sprayed with Bordeaux mixture, adequate control plots being provided. The crops at both centres were graded for scab, counted and weighed.

The Fruit Soils Survey (which is being carried out in co-operation with the East Malling Research Station) was started in the latter part of October. The Advisory Chemist has taken an active part in the work of the Survey as far as his time permitted.

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57. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

1. *Advisory Work amongst Farmers.*—The methods of Neubauer and Mitscherlich for estimating manurial requirements have been tried, and although our experience is still too limited to come to definite conclusions, it would appear that these methods are of considerable value.

2. *Co-operation with County Organisers.*—Field tests for manurial requirements have been carried out in co-operation with two County Organisers and a certain amount of assistance in sampling has been given in connection with the Acidity Survey.

3. *Joint Research Problems with other Departments.*—The work in connection with the late Dr. Smith's vegetation plots on Boghall Hill has been continued, but this work has been seriously handicapped by Dr. Smith's death. Soils have also been examined in connection with research work being carried out by Mr. Kendall (Agricultural Zoology) ; Mr. Gibson (Bacteriology) and Mr. Gordon (Pasture).

4. *Soil Survey Work and the Study of Soil Types.—Field Work.*—The examination of soil types within the College area has been continued and good progress has been made with the Acidity Survey. The field by field survey has been carried out in 16 parts of the College area and very marked differences in acidity have been found. The results already obtained make it clear that in certain parts of the country there is no need for liming—the soils all being alkaline or only slightly acid—whilst in other parts most of the soils are extremely acid.

A very detailed Acidity Survey of the College Farm has also been made.

Laboratory Work.—Over 4,000 pH determinations in duplicate were carried out in connection with the Acidity Survey and attempts are being made to determine by short methods the condition of some of these soils with regard to phosphates. The progress of the work in connection with phosphates has been interfered with by the loss of Mr. Dow who left to take up an appointment elsewhere.

Mr. Stewart (Research Scholar) has continued his work on Potash. He has published one paper dealing with The Availability of the Potassium in some Scottish Soils ; another dealing with Modern Methods of Determining Manurial Requirements ; and a third is ready for publication.

Mr. Muir (Research Scholar) has been studying the nitrogen cycle in a series of soils from the College farm.

The studies of Geology and Mineralogy by Mr. Hart have been continued. He has published one paper and another will appear in the next volume of the Journal of Agricultural Science.

Laboratory facilities have been given to several workers from other institutions, including Mr. Leckie (Kenya); Mr. McLagan (Imperial Bureau of Entomology); Mr. Crookston (Egypt); and Professor Tuirin (Russia).

A meeting at Danzig of the Sub-Committee of the International Society of Soil Science dealing with the Soil Map of Europe was attended by Dr. Ogg.

Mineralogical Analysis of Soil Types.

(*a*) *Soils.*—The soils investigated were taken from the area lying between the Forth and Tweed. This is a district of very varied geology both of bedrock and of drift deposits. The field conditions, profiles and textures were noted and in the laboratory thirty soils were examined mechanically and petrologically. The soils can be grouped on a mineralogical basis, and the mineralogical constitution of the boulder clay (the parent material of the soils) was found to depend on the nature of the underlying rocks. The details are given in: Studies in the Geology and Mineralogy of Soils, Part II Soils of South-east Scotland (*J. Agric. Sc.*, Vol. XIX, pt. 4.)

(*b*) *Glacial Deposits.*—The study was continued into the soils and drift deposits of Kincardineshire, where the geology is very complex. The results obtained so far indicate that there is a distinct variation in the mineral content of the matrices of the boulder clays in this region according to the nature of the underlying rocks and that the soils derived from these clays can be differentiated petrologically.

The mineralogical examination of soils in the east of Scotland gives a useful aid to differentiating and classifying the soils and also information as to the content of potash, phosphate, and lime-bearing minerals.

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58. EDINBURGH: ROYAL (DICK) VETERINARY COLLEGE AND EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Feeding of Chickens.—Eighty-eight pullet chicks hatched on 14th January, 1929, were divided into four groups; two groups were fed on a complex mixture and two on a simple mixture. Each group was sub-divided, one lot being given separated milk to drink and the other lot water. At the end of fifty-six days all birds were put on the same mash, but the milk and water groups were retained as

before ; and at the date of the first egg all birds were put on layers' mash.

The experiment has shown—

(*a*) that the birds reared on the simple mixture plus milk made almost as good gains as those reared on a complex diet plus milk.

(*b*) that the birds reared on a simple diet plus water made slightly greater gains than those reared on a complex diet plus water.

(*c*) that the birds given milk made much greater gains than those given water ; they consumed more food, but less food per unit of live weight increase than the water fed birds.

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59. GLASGOW : WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Soil Survey.—The soil survey of South Ayrshire—in association with the Geological Survey of Great Britain—has been advanced. About one thousand samples have been collected in the field and an approximate analysis of these is in progress. The work has been retarded by staff changes during the year.

The survey of soils in North Ayrshire and Renfrewshire was continued. This work included a study of the heavy clay loams of the Kilbirnie and Dalry coalfield, the brown brashy loams of the igneous rocks of the Renfrew-Ayrshire border, the brown sandy loams of West Renfrew and the extensive range of clays, silts, loams, sands and associated peat of lower Renfrewshire from Houston and Bishopton to Cardonald. In the course of this work numerous farms were visited and soil problems discussed with local farmers on the ground. Soil acidity estimations, numbering about 3,000, were carried out in the field.

Other Work.—The prospects for mole draining in the College area were examined. The application of mole draining to suitable land in Renfrewshire was arranged and an experiment and demonstration of this work was carried out at Barochan, Renfrewshire.

The possibility of utilising the peat resources of Flanders Moss for generation of electricity was examined.

M.

ENTOMOLOGY.

60. ABERYSTWYTH: UNIVERSITY COLLEGE OF WALES.

Further Tar Distillate spraying of fruit trees was carried out, but the proposed programme was seriously curtailed by weather conditions.

Experiments on Root Fly Control were continued. The non-appearance of the Carrot Fly, even on controls, prevented data being collected, but with the Cabbage Root Fly and Onion Fly, interesting results were obtained.

A preliminary series of experiments was carried out against these pests. Very interesting results were obtained. Chlorcresylic acid dust showed much promise, and in each trial covering the plants with soil was found to be definitely detrimental.

Rennie's method of controlling Acarine disease has been further tested with good results.

The study of the Aphididae of the province has been continued.

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61. BANGOR: UNIVERSITY COLLEGE OF WALES.

(1) Investigations concerning Sheep Maggot Fly.

(*a*) A survey of species attacking sheep in North Wales proved *Lucilia sericata* to be the only species involved.

(*b*) The phenomenon of hibernation has been observed.

(*c*) Observations have been made on the duration, under N. Wales conditions, of the different stages of the life history.

(*d*) The minimum period of feeding by the larva essential for the production of an imago has been critically ascertained. This is shown to have a direct bearing upon the method of control at present adopted.

(*e*) Preliminary laboratory experiments have been carried out with different larvicides.

(*f*) No parasites have been bred from larvæ obtained direct from sheep.

(2) Research on the group Collembola (Springtails).

(*a*) Research on fundamental and economic aspects of certain species of Collembola has been continued.

(*b*) The influence of temperature, humidity and other factors upon the incubation period has been ascertained.

(*c*) Gaps in the knowledge of the life history of certain species have been partially filled.

(*d*) Preliminary field experiments on the control of certain species have been carried out. The somewhat conflicting nature of the results of some of these experiments has been explained by subsequent laboratory experiments. These have suggested more promising lines of attack.

(*e*) A study of the collembolan fauna of North Wales, particularly Anglesey, is being carried out.

62. BRISTOL UNIVERSITY.

1. *Tar-distillate Wash Trials.*—Field experiments were carried out on apples (eleven centres), plums (three centres) and black-currants (three centres) in Somerset, Worcester, Gloucester, Devon, Cornwall, Kent, Sussex, Cambs, and the Isle of Ely, and were chiefly concerned with the control of the Apple Capsid Bug (*Plesiocoris rugicollis*). The washes used were (1) the Long Ashton Wash, (2) a modification thereof, and (3) a proprietary " Standard," all at varying strengths.

The outstanding results were the consistent control of Capsid Bug effected by the Long Ashton Wash at 10 per cent. strength, and of caterpillars at 6 per cent. by both the Long Ashton and the Modified Wash.

The ovicidal value of the high-boiling, neutral tar-distillate has been compared with that of its various individual components and also with that of a number of other products, such as " low-temperature " carbonisation tar, wood tar, high-boiling petroleum products, etc. In all 156 trials have been made, involving the use of some 16,000 eggs. Heavy medicinal paraffin, high-boiling " low-temperature " tar and diphenyl oxide all appear to be about as efficient as the " high neutral " tar, but no product of greater efficiency has been found.

2. *Control of Woolly Aphis by means of a Parasite.*—By arrangement with the Ministry of Agriculture a further introduction of the parasite (*Aphelinus mali*) was made into an orchard in the Bristol Province.

3. *Strawberry Problems.*—(*a*) The survey of strawberry plantations was continued, more especially in connection with the incidence of red spider attacks.

(*b*) Work was continued in collaboration with the Plant Physiologist of the Long Ashton Station relative to the problem of " red plant " disease of strawberries, and, in particular, to the relationship between eelworms and " red plant."

4. *Use of Naphthalene for Control of Market Garden Pests.*—Experiments were carried out in Bristol market gardens on the control of the pests *Psylliodes chryscephala* on brassicae, the carrot fly (*Psila rosae*) on celery, and millipedes (*Blanjulus* sp.) affecting potatoes, by means of naphthalene.

63. CAMBRIDGE UNIVERSITY.

In conjunction with County Horticultural Officers the following investigations have been undertaken :—

1. *The Control of Apple Capsid Bugs.*—These experiments carried out partly in conjunction with the Long Ashton Research Station show that a proprietary Emulsified Oil and the Modified Long Ashton Wash gave a moderately good control of the Apple Capsid Bug in the Wisbech area.

2. *The Control of Red Spider on Fruit Trees.*—Results were disappointing owing to the uneven distribution of the pest.

3. *The Control of Carrot Fly.*—Experiments in the Isle of Ely, Huntingdonshire and Norfolk show that Crude Naphthalene Compounds are capable of reducing Carrot Fly and increasing the crop.

4. *The Control of Cabbage Root Fly.*—Results were very largely spoilt by the drought.

The Advisory Mycologist also co-operated in the following experiments.

5. *The Control of Apple Scab.*—Plots similarly treated for three years show that spraying is very profitable indeed over this period and that the results of spraying are cumulative.

6. *Wet versus Dry Spraying of Fruit.*—In these routine spraying experiments scab was so slight as to make comparison difficult, but the wet spraying gave a much better control of the Apple Capsid Bug.

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64. CARDIFF UNIVERSITY COLLEGE.

1. *Liver Fluke Control.*—Tests have been in progress during the past year on the control of Liver Fluke, particularly with regard to the further testing of copper sulphate as a means of eradicating the snails.

2. *Big Bud Mite on Black-currant.*—Tests of lime sulphur spray have been made, largely with the object of demonstrating the efficiency of this method of control of the pest.

3. *Big Bud Mite.*—An apparently immune variety of black-currant is being studied and attempts made to infest some of the bushes experimentally—so far without result.

4. *Cabbage Root Fly Control.*—Naphthalene has been used on a field scale as a means of controlling this pest, and has proved extremely satisfactory. Three dressings were applied at ten day intervals from planting out time.

5. *Onion and Carrot Fly Control.*—The use of Naphthalene as a deterrent has also given good results against these pests.

6. *Apple Tree Red Spider.*—Tests of mineral oil emulsion sprays have given satisfactory control of this pest. Spraying was carried out after the blossom had fallen. Two sprays were used—Volck and Amberol, the latter containing sulphur. The results were equally good in each case.

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65. HARPER ADAMS AGRICULTURAL COLLEGE.

Carrot Fly.—The efficacy of broadcasting different brands of naphthalene, at the time when the fly is depositing its eggs, as a means of control has been tested. Highly satisfactory results were obtained with a brand known as " Drained Creosote Salts."

Onion Fly.—Applications of naphthalene powders to control this pest have been carried out. Dressings of " Drained Creosote Salts " at singling time gave strikingly successful results and effected a commercial control.

Potato Eelworm (*Heterodera schachtii*) *Disease.*—Extensive trials have been continued with special reference to control of this disease. The materials tested are " Drained Creosote Salts," Naphthalene (Grade 16) and Bleaching Powder. The first chemical substance gave the most satisfactory results whilst the last was apparently ineffective and inhibited the normal growth of the plant.

Potato Eelworm (*Tylenchus dipsaci*).—Considerable progress has been made with the investigations on (*a*) soil treatment by certain chemical substances, and (*b*) comparative trials of varieties to determine resistance to attack. Encouraging results have been obtained in both lines of work.

Mangel or Beet Pigmy Beetle (*Atomaria linearis*).—Investigations on the life history, bionomics and control are being carried out. Two lines of control have been attempted (*a*) chemical treatment of the seed, and (*b*) soil treatment by insecticides prior to sowing of seed. Very efficient control has been discovered in seed treatment by phenol and magnesium sulphate.

Cabbage Root Fly.—The main line of work has related to control by means of larvicides and deterrent substances. Marked results have been obtained in the field with the former of these.

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66. LEEDS UNIVERSITY.

1. *Potato Eelworm.*—One of the chief desiderata is a method of observing how the larvæ after emerging from the parent cysts penetrate the potato roots and feed inside. Observations are difficult under natural conditions, but it was found possible to study

the process by infecting roots which had developed in damp soil-free capsules.

2. *Mangold Fly.*—Observations were made on the feeding and mating habits of the fly. Apparently the flies die without mating unless they can feed during the first two or three days after their emergence. The use of naphthalene dressings in shielding plants in the field from attack gave encouraging results.

3. *Black Aphis.*—Attempts were made to fumigate mangolds growing in a field attacked by this insect. Tobacco fumes were found to be effective provided the aphis can be exposed to them for a sufficiently long period. This result can be obtained by covering the plants when they are being fumigated with a screen of suitable size, and moving it along the rows in such a way that each plant is covered for about five minutes. Black Aphis eggs were found in October on French Beans.

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67. MANCHESTER UNIVERSITY.

1. *Investigations on the Biology of "Heterodera schachtii," the Potato Eelworm.*—The life history and development of *H. schachtii* on potatoes has been carefully studied from the first invasion of the fibrous roots of the young potato plant until the production of brown cyst containing young larvæ. The part played by soil temperature and soil conditions has also been investigated. From the work so far completed it is concluded that the potato plant normally possesses a high degree of tolerance of the eelworm and that the mere presence of eelworms in the root tissue is not sufficient to produce pathological conditions in the host plant.

2. *Investigations on "Potato Sickness" in Lancashire.*

Part I.—A Study of the Factors Contributing to the Occurrence of "Potato Sickness."—Under conditions in the North-West of England the eelworm, *H. schachtii* and the fungus *Corticium solani* are invariably present in every case of "potato sickness." Occasionally the fungus *Colletotrichum tabificum* is also present. Observations have shown that the potato plant can tolerate heavy infestation by the eelworm and can recover from severe infection by *Corticium solani* and yet produce a good yield. Where *Colletotrichum tabificum* is present, the fungus appears to accelerate the destruction of roots in the autumn. Under field conditions, where these organisms are present to a more or less constant degree from year to year on "potato sick" areas, complete failure of the plants one year may be followed by a crop producing normal growth and practically normal yield the succeeding year. The conclusion reached is therefore, that "potato sickness" is not necessarily caused by the presence of the parasitic organisms either separately or simultaneously, but is induced by

other factors which alone and in conjunction with these organisms may produce depressed conditions.

Part II.—Soil Treatment for the Control of " Potato Sickness."—Experiments have been carried out on the use of Naphthalene, Calcium Cyanide and Calcium Cyanamide as soil dressings in cases of " potato sickness." In 1928 Naphthalene raised the yield from below 30 cwt. per acre to over 40 cwt. per acre, and Calcium Cyanide to 65 cwt. per acre, thus confirming the results obtained by other workers. In 1929 Calcium Cyanamide was used and this was found to raise the yield from about 8 tons per acre to over 11 tons per acre. In experiments in conjunction with the Ministry of Agriculture using Naphthalene, both crude and pure, and bleaching powder, no definite advantage accrued from the use of Naphthalene in either form under conditions prevailing in 1929, and the use of bleaching powder slightly depressed the yield.

3. *A Study of the Frit Fly Problem in the North-West of England.*—The Frit Fly has been studied under field conditions since 1927 and it is seen that the main swarming periods lag behind those in the South of England. Attack is usually severe on both tillers and grain, and a definite association has been observed between the production of " blind " ears and Frit Fly attack at the base of the panicle. In 1929 tiller attack was as high as 25 per cent., and grain attack as high as 54 per cent. in individual cases. Distribution, varietal susceptibility, and date of sowing in relation to attack, have also been investigated.

4. *A Study of the Slug Problem in the North-West of England.*—Investigations on the biology and control of slugs have been in progress since 1926 and are now concluded. Local conditions have been studied in regard to the development of slugs, and moisture, temperature, organic matter in the soil and soil reaction have been found to influence slug prevalence. Drainage, manuring and cropping have also proved of importance in connection with slug prevalence. Seasonal migration has been investigated and also the part played by natural enemies in limiting the slug population.

In the matter of control laboratory experiments with contact substances have been conducted, and a wide range of chemicals has been tested for repellent effects. Field experiments have shown some benefit from the use of Copper Sulphate worked into the soil before cropping, and washing soda and creosote in precipitated chalk also proved of value. Under garden conditions corrosive sublimate 1 : 1000 has been found of exceptional value as a repellent. Efficient control of slugs is, however, only likely to be obtained by a combination of various methods.

68. MIDLAND AGRICULTURAL COLLEGE.

A census of rooks and a survey of the rookeries in the Province has been made. This has shown their distribution to be not uniform, but to depend on definite œcological factors. The problems of quantity and quality of food consumed, variations at different times of the year, competition with other species, etc., are receiving attention in order to assess the economic status of the species.

The use of poultry against farm, garden and orchard pests has been tested. It is hoped to show the possibilities and limitations of such use. Experiments have been made on a field scale against Carrot Fly attack on Celery, Mangold Fly on Sugar Beet, Mustard Beetle on Swedes, against Slugs and against Canker on Parsnips. Smaller tests have been made against the various vegetable root flies.

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69. NEWCASTLE: ARMSTRONG COLLEGE.

(*a*) *Trials with Various Substances for the Control of Turnip Flea Beetle.*

(1) It would seem that good results may be expected by applying repellents such as paraffin, or something of a finely powdered form to render the leaves obnoxious to the beetles, such as N.A. Phosphate, put on under favourable conditions (when, for example, the leaves are moist, in the case of the powder, and in the absence of rain in the case of paraffin).

(2) The small numbers of beetles found on the areas concerned seemed to showed that nicotine and lead arsenate had a direct killing action on the beetles, many of which probably died at some distance from the plants.

(3) Damage from the Ceuthorrhynchus weevil may be severe at an early stage of the plant's growth, and, as an insecticide, nicotine sulphate gave good results. Paraffin acted well as a repellent.

(4) Nitrate of lime should prove helpful in keeping the soil moist and so rendering conditions unsuitable for the Turnip Flea Beetle, as well as helping on the growth of the plants.

(*b*) *Parasites of the Diamond Back Moth* (*Plutella maculipennis*).

(*c*) *The Control of Root-eating Flies.*

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70. OXFORD UNIVERSITY.

Dr. Cunliffe has continued to concentrate on the problem of breeding new varieties of oats resistant to frit fly attack. About a thousand cross pollinations were done during the season. The percentage of success was low owing to the drought; but seed was

obtained in over seventy cases. Unfortunately the whole of the previous year's crosses (40 plants) were killed by the severe spring frost. In future this class of material will be reared in a glass house in order to avoid repetition of such disasters.

The progeny of the 1927 plants (over 30,000 seeds) were sown. Of these between 4,000 and 5,000 plants were selected as apparently resistant, and were harvested. It is hoped that it may be possible to discard over half of this number on laboratory examination, but it seems that the remaining 2,000 or more should be grown on.

The progeny groups of the third generation were grown on; among these 13 showed a high degree of resistance and at least fair seed quality, and have been retained. Separate selections, made on the basis of recovery power, were grown on. Eleven out of a total of 23 have been retained for laboratory examination.

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71. SEALE HAYNE AGRICULTURAL COLLEGE.

1. *The Nematode Worm* (*Tylenchus dipsaci*).—Work on the "biologic strains" of the nematode is now very nearly complete, but will not be published for some months. Briefly, it has been established that "biologic strains" show a very definite rigidity regarding the specific host plant in which they are able to maintain themselves. At the same time, in a limited number of cases, strains have been found which are capable of reproducing in more than one host. Nevertheless, taking this into account, it may confidently be announced that the strains are of sufficient rigidity to suggest that their origin is exceedingly remote. Work in progress includes attempts to obtain definite data concerning the rate of incidence in previously healthy stocks of narcissus bulbs and serious efforts to work out the detailed biology of the nematode.

2. *The Vine Weevil* (*Otiorrhynchus sulcatus*).—This weevil is a serious pest in commercial glasshouses, particularly on cyclamens and hydrangeas and to strawberries in the open. The life history is being studied in detail, as are suitable control measures. Results to date indicate that there is but a single generation in the year and that parthenogenesis is usual.

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72. WYE: SOUTH EASTERN AGRICULTURAL COLLEGE.

1. Investigations have been carried out on the control of the Apple Capsid (*Plesiocoris rugicollis*) and the Currant Capsid (*Lygus pabulinus*.) Various experiments have been made in Kent and Sussex with Tar Distillates which have been found to reduce the pest

in apples, but not in currants. Experiments with various dusts and sprays have also been made with partial success in apples and complete success in currants, using a 3 per cent. nicotine dust, the soil at the same time being dusted.

The life-histories of the two pests have also been worked out and the importance of greasebanding apples before dusting or spraying has been demonstrated.

2. *Experiments on the Control of Slugs.*—Numerous experiments on the control of Slugs in the field, hop garden and garden have been made. Copper Sulphate and Lime was found the most successful method at the rate of 4 lbs. of finely crushed copper sulphate, 1 cwt. of fine lime to the acre on wheat, broadcast towards the end of the day. Put on hops this caused some scorching, but not on wheat or barley. The ordinary Paris Green and Bran bait was found successful in hops and in gardens when put on thickly. Napthalene at 4 ozs. to the square yard was also successful for the small Black Slug in gardens.

3. Experiments on the control of Earwigs showed that great numbers may be killed by the use of a poison bait made as follows :— Bran 12 lbs., Sodium Fluoride 24 ozs., water 9 quarts and black treacle 6 quarts, broadcast over the infected soil, or glasshouse floor and staging where the Earwigs are working.

The same was found very successful in killing Cockroaches.

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MYCOLOGY
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73. ABERYSTWYTH: UNIVERSITY COLLEGE OF WALES.

The breeding of varieties of oats resistant to Crown Rust (*P. coronata*) continues in co-operation with Mr. E. T. Jones, of the Welsh Plant Breeding Station. New varieties and strains of Oats were tested and some of the pedigree strains showed a high degree of resistance to this fungus. A large number of experiments were carried out on the control of Onion Mildew (*P. schleideni*). Bordeaux Mixture 4–4–40, Iron Sulphate and Flowers of Sulphur were tested; Bordeaux mixture gave the best results but did not prevent the disease entirely. Results obtained from other experiments showed that there is apparently no relationship between the stage of growth of the onion plant and the incidence of Mildew.

The use of resistant varieties of swedes was demonstrated in many areas where Finger and Toe (*P. brassicae*) is prevalent. A co-operative experiment on Blight in Potatoes (*P. infestans*) was carried out in co-operation with other Advisory Mycologists to find out if the potato plant is more susceptible to the fungus at a certain stage of growth. Plantings were made at stated intervals and towards the end of August a heavy attack of Blight appeared on all the plots, thus showing that there is apparently no relationship between the stage of growth and the incidence of the disease. This experiment is being repeated next season.

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74. BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

1. *Swede Diseases.*—Variety trials have been laid down at eleven centres to test susceptibility to Finger and Toe, Mildew, Dry-rot and Bacterial Rot. Field and laboratory tests are being made to determine the initial cause of " dry-rot " attacks in swede crops.

2. *American Gooseberry Mildew.*—Trials are being continued to test the relative efficacy of Ammonium Polysulphide and Green Sulphur as a measure of control.

3. *Bracken Disease.*—Field inoculations with pure cultures of a *Phyllosticta* isolated from diseased bracken have proved successful but no spread to adjacent healthy plants has been observed.

4. *Potato Diseases—other than " Virus Diseases."*—Experiments are in progress to test the resistance to " blight " exhibited by certain crosses from Norway, and to determine—with three varieties—whether there is any relation between incidence of blight and the age of the crop. Several soil disinfectants are being tested for efficiency in controlling " Potato Sickness " in soils.

5. *Potato Virus Diseases.*—Seven varieties are being tested on a field scale for their relative susceptibility to virus diseases. Trials with symptomless stocks of two varieties have shown that "immaturity of seed," as such, confers no advantage over mature seed.

Work in insect-proof glasshouses on symptomatology and methods of infection is being continued.

6. *Production of Seed Potatoes in North Wales.*—A scheme to test the possibility of producing seed potatoes on a commercial scale came into operation in 1928. Work was carried out under standardised conditions in co-operation with growers at nine centres. About 10 cwt. Kerr's Pink, 10 cwt. Great Scot and 5 cwt. Sharpe's Express, special Irish seed, were grown at each centre.

In 1928 the amount of virus disease present in the stocks was small, varied little in the different districts, and reached only ·48 per cent. in the centre showing most infection. Sharpe's Express showed ·46 per cent., Great Scot ·32 per cent., and Kerr's Pink ·24 per cent. Seed from stocks was readily marketed at favourable prices.

Produce of the stocks was grown again at the same centres in 1929. At eight centres the total virus disease remained low and varied from ·14 per cent. to ·38 per cent., showing a slight decrease from 1928. Great Scot contained ·4 per cent., Sharpe's Express ·26 per cent., and Kerr's Pink ·14 per cent. virus disease. At the ninth centre a definite increase in the amount of virus disease occurred—1·63 per cent. as compared with ·31 per cent. in 1928.

A smaller but similar scheme with Scotch seed of Kerr's Pink and Great Scot was started in 1927. Where the conditions of this scheme have been observed, the stocks have been maintained for three years without appreciable increase in the amount of virus disease.

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75. BRISTOL UNIVERSITY.

Strawberries.—Aphis plant and "red plant."—Attempts were made to transmit "red plant" by transferring the aphis *Capitophorus fragariae,* from diseased plants to healthy seedlings under insect-proof cages. In no case was there positive evidence of current season infection. On the other hand L. N. Staniland's observations were corroborated, that plants may become permanently dwarfed by the presence on them of aphids from healthy plants.

Asparagus "sickness."—Further investigations of this trouble, which is prevalent in the Evesham area, indicate that none of the fungi (mainly species of *Fusarium*) or bacteria commonly associated with it are capable of effecting the characteristic rotting of the roots. There are indications that it is especially prevalent on potash-deficient soils and can be largely remedied by applications of potash.

Dwarf Beans.—Foot Rot.—This disease, which is very prevalent in the Evesham area, was found to be due to *Fusarium martii.* var.

Phaseoli, previously unreported in this country. Trials are being carried out to determine whether any varieties are to any extent resistant to the disease.

Peas.—Foot Rot.—A foot rot of peas, which is also very common in the Evesham area, has been found to be due to a species of *Fusarium.*

Vegetable Marrow Mosaic.—A mosaic of vegetable marrows in the Bristol area was found to be associated with the presence of *Aphis gossypii* and the disease was transmitted to seedlings by its agency.

Potatoes.—"Sickness."—Pot experiments indicated that this disease is not due to *Corticium Solani*, which is commonly associated with it.

Hops.—" Nettlehead."—Although field observations appear to indicate that this disease belongs to the virus group, attempts at its transmission by means of the aphis *Phorodon Humuli* have as yet been unsuccessful.

Willow.—Rusts.—Work on the willow rusts indicates that the *Melampsoras* on *Salix alba, Salix triandra* and *Salix fragilis* are distinct.

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76. CAMBRIDGE UNIVERSITY.

Wheat.—Bunt (*Tilletia caries*).—(*a*) The control of this disease has been studied, the work concluded and the results published.

(*b*) An investigation has been made and recorded on the price that the farmer obtains for bunted samples of wheat. It has been shown that even a slight contamination may result in a loss per quarter of 1s. 6d.

(*c*) Work on the resistance of wheat varieties to bunt has been continued. It has been shown that "immune" varieties may be markedly susceptible.

(*d*) The effect of bunt on the development of the wheat ear has been recorded and the information published.

(*e*) Further work on the spore load, the rate of sowing, and the date of sowing has been carried out. The results await publication.

Wheat.—Yellow Rust (*P. glumarum*).—(*a*) Work has been published on the intensity of this disease on certain wheat varieties.

(*b*) Observations have been recorded on Brown and Black Rust.

Sugar Beet.—Work has been completed on the control of Blackleg disease in sugar beet. The results have been communicated to (*a*) the scientific Press, (*b*) the lay Press.

Potato.—(*a*) An experiment was carried out on the date of sowing potatoes as a factor influencing blight. The experiment was negative as blight did not appear.

(*b*) Spraying experiments for control of blight. Blight did not appear on the crop.

(*c*) Preliminary observations on a wet-rot of potatoes in the clamp. This is now under investigation at the Pathological Laboratory, Harpenden.

Apple.—Apple Scab control.—Plots similarly treated for three years show that spraying is very profitable indeed over this period and that the results of spraying are cumulative.

General.—Gibberella saubinetii has been discovered in this country and was diagnosed for the mycologist by Dr. Bennett.

Observations have been made on Dörrfleckenkrankheit of oats and " foot rot " of cereals.

Observations on the bacterial and fungal flora of the upper air have been made.

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77. CARDIFF: UNIVERSITY COLLEGE.

1. *Hay Mixtures.*—Experiments with different grass and clover mixtures for hay have been continued.

2. *Sainfoin.*—Investigations mainly with regard to the nature and persistence of different strains, and on the time and depth of sowing are being carried out at the Green Farm. One strain from Glamorgan seems to be particularly persistent. Investigation on the stage of cutting with respect to feeding value and yield has been carried out in co-operation with Mr. Fagan of Aberystwyth. Further field plots have been laid down in Glamorgan—the plots including local, Cotswold, Hampshire and Eastern Counties seed.

3. *Lucerne.*—Plots laid down at the Green Farm in 1927 and kept under observation as regards permanency and hardiness are continued.

4. *Finger-and-Toe.*—The Danish swede "Wilhelmsburger " has been sown at four centres in Glamorgan and three centres in Monmouthshire to compare its resistance with that of varieties in ordinary cultivation.

5. *Potato Blight.*—A co-operative experiment with the Plant Pathological Laboratory of the Ministry of Agriculture and Fisheries was conducted at the Green Farm to see whether a correlation existed between the date of planting and the date of incidence of Blight. All the plots were attacked within about five days.

6. *Tomato Leaf Mould.*—Home made and proprietary materials were tested against tomato leaf mould at a Swansea nursery and at Green Farm. Conditions, however, were not favourable to the disease at these centres.

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78. HARPER ADAMS AGRICULTURAL COLLEGE.

Control of Finger and Toe Disease.—This work was continued and extended to include methods of treatment applicable to farm crops. Data were obtained from experiments started in the previous year showing that *Mercuric chloride,* when used at concentrations of 1 in 1,500 and 1 in 2,000 respectively, was equally effective in con-

trolling the disease as when applied at higher concentrations. It was also found that these dilute solutions caused no such appreciable check to growth as was often apparent where the originally-tested 0·1 per cent. solution was applied.

Mercuric chloride applied in minute quantities in the dry state effectively checked the disease but caused serious damage if applied directly to the plant roots.

Mercurous chloride, used dry, again gave good control without producing any noticeable adverse effect upon the plants.

Trials carried out with *Calcium cyanamide* gave inconclusive results.

Potato "Blight" Experiment.—An experiment, in co-operation with other advisory centres, was carried out with a view to ascertaining any possible relationship between the incidence of "blight" and the age of the potato plant.

Laboratory Work.—Research work on certain parasitic fungi was conducted in the laboratory and is being continued.

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79. LEEDS UNIVERSITY.

Net Necrosis of Potatoes.—An organism was isolated from tubers sent by Atanasoff as specimens of the Net Necrosis disease he has described. The pathogenicity of this organism is being tested in pot cultures.

Bracken Disease.—A fungus has been isolated from diseased material which under greenhouse conditions easily reproduces the disease by inoculation. Field inoculations produced much less satisfactory results and it remains to be seen whether the disease which appeared will be intensified next year.

Pink Rot of Potatoes.—The results of field trials for the control of this disease have shown that a very satisfactory reduction of the disease followed the application of sulphur at the rate of 3 or 6 cwt. per acre or of sulphate of potash at the same rates. Variety trials for resistance to the disease are now in progress.

Leaf Spot of Oats.—The symptoms of the disease due to *Helminthosporium avenae* have been dissociated from those of cognate diseases whilst a detailed study of the morphological and cultural characters of the causative organism has also been made. Examination of eight varieties of new seed from Scotland showed seven of these to be infected by *H. avenae*, one up to 40 per cent. Satisfactory control of seedling infection was given by treatment of the seed with formaldehyde.

The mode of attack by Actinomyces and the subsequent Development of Scab in Potato.—The object of this investigation has been to ascertain the nature of the response of the tuber to the attack of the organism. For this purpose the histogeny of both pitted and raised scabs, whether of natural or artificial origin, has been studied.

Halo Blight of Oats.—An investigation of a disease which resembles in many respects the Halo Blight of Elliott or the German Dörrfleckenkrankheit is being started. No correlation between soil reaction and the incidence of the disease has yet been observed. An organism from leaf lesions is now being tested.

80. MANCHESTER.

Trials of resistance to White Rot of certain varieties of onions showed that English saved seed of the more resistant varities was superior to foreign saved seed, not only as regards resistance to White Rot, but also in purity and germination.

From preliminary observations on the relations between the incidence of Potato Blight and the condition or age of the plant foliage it was concluded that the later the crop could be planted the less susceptible it would be to attack.

Preliminary experiments in seed dressing rye with a saline solution as a means of controlling Ergot of Rye gave most encouraging results.

Spraying trials for the control of Apple Scab were carried out at six centres and have proved the superiority of lime sulphur over Bordeaux Mixture in the North-West of England.

Celery Blight was effectively controlled by treating the seed and the soil prior to sowing with a weak sterilising solution of formaldehyde, followed up, where necessary, by spraying the plants with Bordeaux Mixture.

A slightly modified form of the sublimate treatment of the soil, first in the seed bed, and afterwards in the field, at planting out time, proved to be an effective means of controlling Club-root of Brassicae.

81. MIDLAND AGRICULTURAL COLLEGE.

1. *Celery Diseases.*—Most of the seedling diseases in the frames are prevented by partial sterilisation of the soil with formaldehyde. This treatment is even effective with badly infected soil which has been used for raising celery seedlings for ten years or more. The cheapest and most effective way is to treat the soil in the frames, using four gallons of 2 per cent. formaldehyde for each 6 ft. by 3 ft. light. Covering the soil with wet sacking is unnecessary if the lights are kept on for a couple of days.

Further work confirms the view that *Phoma* Root Rot (*Phoma Apiicola*) is a seed borne disease and can be only partially controlled by seed treatment.

Leaf Spot or Blight (*Septoria apii*).—All seed treatments tried for the prevention of this disease only partially control it. The efficiency of spraying infected crops with various wet and dry fungicides for the control of this disease in the field has been proved. Perfectly clean celery seed, entirely free from infection

with *Septoria apii*, has been produced at nine centres by regular spraying of the seed-producing plants; this seed has in all cases produced plants without a trace of *Septoria* attack. Experiments with naphthalene against Carrot Fly attack on celery have given promising results.

2. *Black-leg in Sugar-beet.*—Further experiments on a field scale have shown that treatment of the seed with warm, weak, copper sulphate solution greatly reduces the amount of this disease in the seedlings.

3. *Parsnip Canker.*—Further variety trials have been carried out at two centres with a view to finding a variety of parsnips resistant to the trouble known as Canker.

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82. NEWCASTLE : ARMSTRONG COLLEGE.

Potato Blight.—An experiment was carried out on the relation between the age of a potato plant, and the incidence and development of Potato Blight on it, under a general scheme laid down by the Plant Pathological Laboratory of the Ministry of Agriculture and Fisheries. The results show that for a given variety the incidence of Blight is dependent upon seasonal conditions and not upon the age or stage of development of the plant; and that the disease, when established, does not make such rapid progress in, or kill off so readily, the haulm of younger plants.

The Vigour of a Northern Potato Stock.—Seed potatoes from "Arran Comrade," grown for eight years in Westmorland, were grown in the ninth year in Cambridgeshire, and seed from these plants was grown alongside the original stock in the tenth year. It was found that the single season's growth in Cambridgeshire vastly increased the amount of Virus Disease present. In the following year the deterioration in the haulm was extremely marked and the yield of tubers greatly reduced.

Resistance of Onion seed to Smut.—Tests were carried out on a variety of onion advertised by seedsmen as immune to Onion Smut, the test being conducted in a greenhouse, outdoors, and under normal conditions in a market garden where Smut occurs naturally. The variety was shown to be not more resistant to the disease than an ordinary known susceptible variety.

Bacterial Shot-hole of Peach.—Two lime sulphur washes and a nicotine wash were tried. The most successful was the nicotine wash, 1 in 40, which caused no defoliation and gave excellent control.

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83. OXFORD UNIVERSITY.

Oak Mildew.—The work carried out in collaboration with J. S. L. Waldie and H. M. Steven has been continued, and a successful method of control has been established. A full report has been published.

Apple Mildew (*Podosphaera leucotricha*).—This continues to be the major problem under investigation and a considerable measure of success has attended the attempts to control the disease by sprays. It is hoped that a preliminary report will be published in the coming year.

Leaf Spot in Beans (*Cercospora Fabae*).—Some progress has been made in the study of this recently-discovered disease, isolations and inoculations having been successfully made. This work will be continued for at least another year.

Sugar Beet.—The results of the investigation on the chemical treatment of sugar beet seed have been published, both in the appropriate scientific journal and the technical press.

Wheat.—A further large scale trial has been put down with wheat in order to test the respective effects of the three standard bunt-preventive treatments on the yield of the crop. A simple machine for the application of copper carbonate to seed wheat has been designed, and a descriptive leaflet has been printed.

Oats.—An attempt is being made to assess the damage done by the Leaf Spot disease of oats, *Helminthosporium Avenae*, and to investigate its life history.

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84. READING UNIVERSITY.

The main line of research has been on the disease of swedes caused by the fungus *Phoma Lingam*, previous investigational work having been stimulated into more active research by the publication of Cunningham's paper in New Zealand in 1927.

Research at Reading has shown that :—

(1) The fungus *Ph. Lingam*, in the strictest sense, not only causes Dry Rot in crops of roots, but also is constantly associated with, and is probably the principal causative agent of, the disease known to growers of crops of swede for seed as " Canker."

(2) *Ph. Lingam* occurs on the leaves, stems and siliquas of " seed plants," and the seed can thus become infected to a very slight extent even in a dry summer. However, examination of a large number of commercial samples of seed dating from before the last two very dry seasons (which incidentally have seriously hampered the work) has not revealed the presence of more than four or five infected seeds per thousand in any sample.

(3) The amount of infection in seed is minimised by badly cankered crops usually becoming a total loss.

(4) Species of *Macrosporium*, *Alternaria*, etc., are extremely common in swede seed, adding considerably to the difficulty of seed examination, and work carried out here (also independently by Murphy in the Irish Free State) shows that Cunningham was led in error to include some of these non-Phoma fungi within his species *Ph. Lingam*.

(5) Although genuine *Ph. Lingam* does occur in seed yet it does not appear to anything like the extent which Cunningham originally claimed.

(6) The rate of spread of the disease through crops is being examined. Soil infection occurs, and it is difficult to demonstrate clearly how far soil infection, and how far minute amounts of seed infection, are responsible for the quantity of disease in the mature crop. Soil infection appears to be at least as important as seed infection in the south and east of England.

(7) Cunningham now verbally admits soil infection under our conditions, and also that his method of seed treatment fails to eliminate the disease entirely from seed: therefore the method laid down by him for British seedsmen to adopt in growing the supplies of seed for New Zealand breaks down completely, and is equally useless for home supplies.

A share has been taken in the co-operative work on Potato Blight arranged by the Conference of Mycologists. Blight has been completely absent from the experimental plots.

Satisfactory results have been obtained from the use of corrosive sublimate solution against Finger and Toe in Cauliflowers. The method of dipping the roots of seedlings in clay puddled with corrosive sublimate failed to give good results.

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85. SEALE HAYNE AGRICULTURAL COLLEGE.

1. *Potato Blight.*—The co-operative experiment planned by the Plant Pathological Laboratory, Harpenden, on the relation of the age of potato plants to the incidence of blight, has been carried out by means of plots in triplicate. The results have shown that older foliage is not necessarily attacked first.

The local weather conditions have been studied and the records correlated with the progress of the disease in the above experiment.

2. *Control of Black Leg of Mangolds.*—Seed from fifteen different farms in Devon and Cornwall was treated with Uspulun and Tillantin. Black Leg due to *Phoma betae* failed to appear; that due to *Pythium De Baryanum* occurred in two cases and was not affected by the treatment.

3. *Ascochyta Diseases of Peas and Beans.*—Last year's cross inoculations were repeated and extended, but the results cannot yet be summarised.

4. *Control of Tulip Fire.*—The progress of the disease has been studied in detail and it has been clearly shown that clean bulbs can be raised from a diseased crop which, if planted in fresh soil, will produce a healthy crop next year.

5. *Narcissus Diseases.*—Inoculation experiments and observations on *Ramularia Vallisumbrosae, Stagonospora Narcissi,* Yellow Stripe and *Botrytis polyblastis* have been carried out.

86. WYE: SOUTH EASTERN AGRICULTURAL COLLEGE.

Downy Mildew of the Hop (*Pseudoperonospora Humili*).—Investigations regarding the best methods of control have been continued, with special reference to spraying with new machinery and to the removal of diseased growths ("spikes"). The labour required for the latter has been estimated by regular visits to a hop farm.

Virus Diseases of the Hop.—Under a grant from the Ministry of Agriculture investigations with regard to mosaic disease by means of grafting have been continued for the third consecutive season. Preliminary experiments with "nettlehead" have been carried out. A new disease (characterised by the presence of chlorotic areas in the leaf and by abnormal growth) occurring in Worcestershire has been investigated and shown by grafting to be transmissible.

Apple "Scab."—In collaboration with the Chemical Research Department, large-scale spraying experiments have been carried out on the College Farm and on a farm at Teynham, Kent. Plots of four commercial varieties of Apples have been sprayed with either home-made Bordeaux Mixture or Lime-sulphur. Several tons of apples from sprayed and unsprayed plots have been graded by hand for the amount of "scab" present.

Experiments with Fungicides.—In collaboration with the Chemical Department, biologically-controlled experiments with various fungicides have been carried out.

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87. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

The Advisory work in Agricultural Botany was interrupted in the year under report by the death, on 8th December, 1928, of Dr. Smith, the Advisory Officer. The post of Advisory Officer remained vacant until the end of the academic year.

Prior to his death, Dr. Smith was continuing the experimental work on hill pastures at Boghall Glen, and a memorandum on the work has been prepared from Dr. Smith's papers by Mr. J. C. Innes, late Technical Assistant to the Advisory Officer. This memorandum has not yet been revised for publication.

The investigation in co-operation with the Pasture Sub-Committee of the Development Commission was continued at two centres, the scope of the investigation having been extended to include the effect of nitrogenous manuring.

Intervarietal Differences of a Chemical Nature in the Potato.—The investigation was commenced in 1928. Having selected p. cresol as the most suitable reagent as a means of distinguishing between

tubers of similar appearance, the effect of temperature and concentration on the rate of reaction was established. The effects of the age of the plant and its environment have been examined in detail by observing throughout the growing season plants of six varieties grown at six different centres. It would appear that maturity is an important factor in the results obtained, whereas environment exerts little or no influence.

A study of this season's crop is being carried out to ascertain whether there is a seasonal factor and also to confirm last season's results. Certain diseases such as scab and blight, and abnormal conditions such as " greening " and " injury " have been shown to have a marked effect on the chemical tests. These are being further investigated.

Varietal differences in reaction of tuber sap were observed. The study of the acidity was followed up with the aid of a specially constructed electrode. Results indicate that pH value of a tuber is influenced by its state of maturity and the conditions of storage.

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88. GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE.

(*a*) *Eelworm Disease on Potatoes.*—Work on this very serious disease of potatoes was continued during the past year. As the life history of the parasite had already been worked out, it was a question of trying to devise some economical measure of control. So far the most striking results have been secured by applying a heavy dressing of dung in the drill at the time of planting. This is very seldom done in Ayrshire, the dung or the seaweed being applied to the ground before ploughing. The use of green manuring crops such as Mustard, Lupines, and Melilot clover is being tried. Steps will have to be taken to control the spread of this disease. Infection of fresh ground can be traced to the potato tubers used for planting. There may be as many as 15 cysts (the cyst is the lifeless female containing on an average 300 eggs) on each sett used for planting, and this means that on planting an acre over 300,000 cysts are introduced.

Soil investigations show that the majority of the Ayrshire soils are infected. The highest number of cysts recorded was 150 per 10 ccs. of soil—an extraordinarily high count.

(*b*) *Leaf Stripe or Helminthosporium disease on Oats.*—Work on this disease was also mainly directed to securing efficient control measures. Wet seed treatment with the disinfectant Uspulun was successful in increasing the germination in the field from 54 per cent. to 95 per cent. With dry powder treatment, with Tillantin R., the germination was 93 per cent. This disease is by far the most prevalent disease of cereals in the S.W. of Scotland and is responsible for very heavy losses to farmers.

(*c*) *Brown Patch.*—This disease affects grasses in permanent pasture, lawns and bowling greens. It is caused by species of *Rhizoctonia*. It is responsible also for the condition of very many of the poorest pastures. Efficient control has been secured. Publications on these three investigations are in course of preparation.

(*d*) *Strawberry Disease Investigation.*—The Scheme of Investigation was of a practical character involving plot experiments, a series of pot tests, and cross breeding of an immune " wilding."

It had been determined that such cultural or manurial methods as are usually associated with " good cultivation " did not offer any resistance to infection, and the original method of experimentation, viz., treating the soil with soil sterilisers and spraying was reverted to.

From the beginning of the investigation it had been observed that all general methods of soil sterilisation gave some benefit, but that some of these were not commercially feasible, while all were difficult, especially under Scottish climatic conditions.

The plots were arranged with a suitable number of controls to test the efficacy of (I) Gaslime, (II) Cresylic (waste) lime, (III) Corrosive sublimate, (IV) Sulphur in excess, (V) Carbon bi-sulphide, (VI) Cresylic acid.

No method has proved quite satisfactory. The order of effectiveness was : I. Cresylic acid, II. Cresylic lime, III. Carbon bi-sulphide.

Carbon bi-sulphide is more effective on heavy than on light soil.

Further observation confirms the opinions that—

I. Red Cone in root is a definite sign of disease.

II. Most stocks of plants are more or less seriously affected.

III. Clean plants will grow on clean soil.

IV. The disease remains in soil in the decayed roots of the plants and can be carried by implements, etc.

V. The periods of maximum pathogenic activity are late autumn and spring.

VI. Resistant spores cannot be killed by ordinary measures.

VII. A few of the Canadian varieties and Tardine de Leopold are more resistant than the local varieties.

VIII. Some " Certified Stocks " are infected.

O.

VETERINARY SCIENCE.

89. BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

The chief research problems are still those which relate to the treatment and control of liver rot of sheep. Further studies of the efficiency of carbon tetrachloride confirmed the relationship between the dose administered and the age at which the fluke is assailable. Dosage with 20 c.c. showed only slightly greater efficiency than dosage with 10 c.c., the latter amount destroying many of the flukes which were only four weeks old and almost all five weeks or older. The administration of 5 c.c. killed those parasites which had been ingested as cysts eight or more weeks previously. The investigation of the toxicity of the drug to ruminants yielded results which, while largely negative in nature, were suggestive, and the ground was prepared for further work.

The tetany which is met among mountain ponies which have just completed a journey by rail has been studied. Blood analyses indicated that it was true tetany of the type due to an alkalosis—the calcium content of the serum was low, the phosphorus and alkali reserve figures high, and bile pigments were present in each sample. The subcutaneous, or, in the mare, intramammary injection of air had a very marked curative effect and produced a relatively rapid approach to normal in the figures obtained on analysis of the blood.

The Causes of Occasional Intolerance among Ruminants to Dosage with Carbon Tetrachloride.—Field evidence suggested that factors associated with management and feeding rendered some flocks and herds much less tolerant to carbon tetrachloride than is usual. It also made it appear that there is some general reduction in tolerance during the late winter and early spring months.

During the investigations of the past year biochemical analysis of the blood of experimental animals was a feature of the work. The analyses—285 samples were completely analysed—were made at the Courtauld Institute of Biochemistry, Middlesex Hospital, under the direction of Professor E. C Dodds.

Welsh Mountain wether lambs were used to test the effect of certain modes of management on tolerance. Except in a single instance, the drug was always well tolerated. In this exceptional case mild toxic symptoms were seen, and then only did a departure from the normal appear in the blood figures of the post-dosage period.

To test the effect of repeated dosage with 5 c.c. six mature wethers were dosed at monthly intervals during the November–March period of the year. No chemical or biochemical evidence of intoxication was seen at any time. A single sheep was dosed with 5 c.c. of the drug on twenty-two consecutive days and showed no reduction in tolerance.

A biochemical investigation of the blood of six in-lamb-ewes and two mature wethers through the winter and spring was undertaken.

Variation from the normal figures was only seen in samples taken just after the severe snowstorm of early February. Then the values for calcium and phosphorus in the blood of each of the ewes—but not of the wethers—was below normal.

Cautious experiments with cattle showed that they might prove much more suitable subjects for the investigation of this problem.

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90. CARDIFF: UNIVERSITY COLLEGE.

1. *Anaemia in Sheep.*—This particular form of Anaemia appears to have no connection with parasites, either macroscopic or microscopic. An outbreak has been successfully treated by means of injections of anti-anthrax serum. This method was first adopted by a French Veterinary Surgeon with whom the writer conferred while in France.

2. *Calcium Deficiency in Ewes.*—Affected ewes showed symptoms similar to those of "Milk Fever" in cattle. Experiments were conducted with Calcium lactate and Cod-liver oil, the blood having been found to be deficient in calcium. The experiments gave encouraging results.

3. *Partial Paraplegia in Lambs.*—An affected lamb was treated by electricity and internal administration of Cod-liver oil and showed considerable improvement. Controls did not improve in the least.

4. *Fowl Typhoid.*—Vaccination against Fowl Typhoid in South Wales is being carried out, using vaccine prepared by the Ministry of Agriculture Veterinary Laboratory. Results are very encouraging.

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91. LIVERPOOL UNIVERSITY.

Amongst a large number of diseases which have been dealt with mention may be made of the experimental vaccination of calves against tuberculosis upon heavily infected farms. One farm has over seventy vaccinated animals.

A comparison of various methods of testing animals with tuberculin has been made and the intra-dermal method demonstrated to practitioners.

In work upon "Johne's Disease" in cattle during the year 150 animals were tested with a diagnostic agent for the disease, and over twenty post-mortem examinations were held upon animals which had reacted. Experimental treatment was conducted with derivatives of Chaulmoogric Oil and other drugs. No drug appeared to be curative. The diagnostic material used appears to be an aid in eliminating Johne's disease from a herd.

Among diseases of sheep outbreaks of Lamb Dysentery have been dealt with satisfactorily.

Weather conditions and methods of management appear to have an influence upon the incidence of the condition. Few cases occurred this year. Some post-mortem examinations and biochemical analyses of urine and blood were made. Management of the flocks was studied in the disease areas and suggestions made were carried out by the stockowners.

Pregnancy Disease in Ewes.—This condition in ewes during last season was almost absent over the wide areas of Yorkshire where it usually occurs and has in past years caused such a heavy total mortality.

Two seasons have now been devoted to efforts to obtain material for investigation purposes. In the 1928 season the disease caused only very light losses and nine cases only were obtained. In the 1929 season the disease was practically absent and only two cases were obtained.

Suggestions have been put forth that pregnancy disease in ewes is due to a hypocalcaemia. In the two cases in 1929 the blood calcium reading was 8.4 and 8.8 mgs. per cent. respectively whereas a normal pregnant ewe from the same district gave a reading of 7.76 mgs. per cent. One sample was divided and half sent to Edinburgh University which confirmed the findings in Liverpool University.

Notwithstanding the absence of cases of the disease, residence of the Veterinary Adviser and Prof. Gaiger in the affected areas, and contact over a wide area with those who usually suffer losses, contributed in some measure to our further knowledge of the condition and the circumstances under which it occurs.

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92. NEWCASTLE: ARMSTRONG COLLEGE.

Prevention of Lamb Dysentery.—An experiment was conducted in the spring to test the preventive value of hyperimmune "L.D." antisera, when injected into pregnant ewes one week prior to lambing. One antiserum was prepared in sheep and was therefore homologous, while the other was of horse origin and therefore heterologous. Controlled experiments were carried out on several dysentery infected farms, and the results noted. The experiments clearly showed that the injection of "L.D." homologous antiserum into pregnant ewes is yet another method of protecting lambs from dysentery and although not superior to the Toxin Anti-toxin mixture method in this respect, may be used in certain circumstances. Following the use of heterologous "L.D." antisera, protection is not so marked, and the death-rate was comparable in amount with that noted among the control or untreated animals.

Braxy or Sickness in Hoggs.—Trials were carried out with a single dose vaccine known as Anaculture (V. septique toxoided whole culture). It seems that this method is sufficient to induce immunity against the naturally occurring disease. The results of these field trials will shortly be published.

Joint Ill in Lambs.—An investigation into Joint Ill in lambs was carried out in the early part of the lambing season, the results of which it is hoped to publish soon. Enquiries were made into another disease of lambs, which appears to affect the limb bones of animals about two weeks old. Pathologically this disease resembles *fragilitis ossium*.

Grass Ill in Lambs.—In collaboration with the Adviser in Dairy Bacteriology, Mr. D. W. Henderson, B.Sc., the disease known as Grass Ill was investigated, a fully-equipped field laboratory being used for this purpose. A full account of this work will be published at an early date.

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93. WYE: SOUTH-EASTERN AGRICULTURAL COLLEGE.

The Study of Helminth Parasites of Domestic Animals in South-Eastern England.—These investigations continue work begun earlier, Morgan's technique being used.

Sheep.—The parasites examined, with one exception which died on a local farm, were all obtained in Wye from animals slaughtered for food. In all, the alimentary canals of 76 sheep and lambs were examined during the session. The following parasites were found :— *Bunostomum trigonocephalum* (Rudolphi, 1808) Railliet, 1902; *Œsophagostomum venulosum* (Rudolphi, 1809; Railliet, 1896; *Hoemonchus contortus* (Rudolphi, 1803) Cobb, 1898; *Ostertagia circumcincta* (Stadelmann, 1894) Ransom, 1907; *Ostertagia trifurcata*; *Cooperia curticei* (Railliet, 1893) Railliet & Henry, 1909; *Cooperia onchophora* (Railliet, 1898) Ransom, 1907; *Nematodirus fillicollis* (Rudolphi, 1802) Ransom, 1907; *Trichostrongylus*; *Strongyloides papillosus* (Wedl., 1856) Ransom, 1911; *Trichuris ovis* (Abildgaard, 1795) Smith, 1908; *Capillaria longipes*, Ransom, 1911; *Moniezia*.

It will be seen that *Chabertia ovina* (Fabricius, 1788) Railliet & Henry, 1909, is absent from this list: in 73 large intestines examined not a single example was found.

On several occasions *Cystercercus* was collected and Liver Fluke twice, while lung worms were seen in one microscopical preparation.

Pigs.—From a pig killed at the Research Station, Wye, 31st October, 1929, the following were identified :—

Stomach: *Hyostrongylus rubidus* (a few);
Small Intestine: *Ascaris suis* (2);
Large Intestine, etc.: *Trichuris suis* (2).

Students who have been interested in the work have made microscopic examinations of material and have helped in its preservation.

P.

DAIRY BACTERIOLOGY.

94. ABERYSTWYTH: UNIVERSITY COLLEGE OF WALES.

(*a*) *Actinomycetes in Dairy Products.*—Various species of Actinomycetes were isolated from cowshed air, food material, milk, butter, cow-manure, etc., and the action of various strains on milk and dairy products investigated.

(*b*) *Normal and abnormal flora of cows' udders.*—A comparison was made of type and number of bacteria in normal udders and in cases of mastitis.

(*c*) *Bacteriological investigations in connection with milking machines.*—A comparison was made of bacterial flora of milk produced by hand milking and by two types of milking machines. The bacteriological results in the case of the milking machines under ordinary farm conditions are quite as good but not better than in the case of hand milking.

(*d*) *Bacteriological investigations with fresh and artificial cream.*—Microscopical examination, plate count, Reductase and fermentation tests are suggested as tests to distinguish these two types of cream. Artificial (reconstituted) cream has a lower bacterial content and a better keeping quality than fresh cream.

(*e*) *Bacteriological examination of Milk Powder.*—The cause of the anaerobic stormy fermentation set up in artificial cream has been traced to the milk powder used. A bacteriological study of different types of milk powders is being carried out, with special reference to the presence of anaerobic spore formers.

(*f*) *Bacteriological examination of Ice-Cream.*—A study of the hygienic production of ice-cream is being carried out in conjunction with five local manufacturers.

(*g*) *Microbiological examination of butter.*—A study of the correlation between bacterial counts, mould and yeast counts, and scoring and keeping quality, has been carried on for three sessions and is being extended along the following lines:—

(1) Microbiological comparison of imported and local farm butter.

(2) Action of various bacteria, moulds, and yeast isolated from milk, water, and butter on sterilized butter fat.

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95. BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

Investigational work has been carried out chiefly in regard to high bacterial counts and the presence of *B. Coli* in the milk supply. In one instance it was found that the wire gauze used in the strainer was the cause of the trouble, sour milk

having accumulated in the mesh through imperfect washing. The farmer was advised to dispense with the gauze discs and use only filter cloth as a straining medium, and this having been done there was a distinct improvement in the bacteriological quality of the milk.

In another instance the results obtained from a farm in the clean milk competition were not as satisfactory as were expected considering the cleanly conditions under which the milk was produced. Cows and cowsheds were very clean and all the utensils were scalded with boiling water. Investigation disclosed the fact that the water used for washing and scalding contained a heavy deposit of iron, and in order to avoid this deposit remaining on the utensils everything was wiped with a cloth which was not sterile, thus destroying all benefits of scalding. The farmer was advised to fit up a steriliser by utilising the farm copper, by means of which all utensils could be sterilised and thus obviate the necessity of wiping with a cloth. This was carried out with complete success, and results were such that this particular farm was enabled to win the first prize in the clean milk competition of the following year.

Other investigations have been made into the cause of taints in milk, and in each case investigated it has been found to be due to an infected udder or quarter of one of the cows, and in such cases, the affected milk being kept out of the bulk, the trouble has automatically disappeared.

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96. BRISTOL UNIVERSITY.

1. The investigations into abnormally high counts in milk produced under apparently clean conditions are being continued.

2. A study of the souring of milk at the same period every year has been made and the trouble has been traced to recurrent mastitis due to the presence of *Staphylococcus Pyogenes.*

3. In collaboration with the Medical Officer of Health, the Agricultural Department, Wiltshire County Council, and the Royal Agricultural College, Cirencester, an investigation in connection with tuberculosis in cattle kept under the " open-air " system is being conducted.

4. " Gassiness " in cheese and souring of milk have been examined ano large number of farms and in the majority of cases the trouble has been found to be due to the insufficient cleansing of utensils.

5. The condition known as " Black Mould " in butter is being investigated in co-operation with the Research Mycologist.

6. At the request of the Ministry of Agriculture and the Somerset Agricultural Department, the problem of taints in Cheddar Cheese is being investigated and it is hoped to make a comprehensive survey of the cheese producing farms in Somerset, for the purpose of ascer-

taining, if possible, the cause or causes of this condition of Cheddar Cheese.

7. An investigation into the "Effect of Different Balanced Rations on the Yield and Composition of Milk from Dairy Cows," which was being conducted in collaboration with the Adviser in Agricultural Chemistry, has now been completed and a bulletin on the subject has been published by the University.

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97. CAMBRIDGE UNIVERSITY.

1. A case of ropy milk was traced to infected water supply. Steam sterilisation of utensils, combined with the use of boiled water for washing the cows, lessened the trouble, but it was not until the water used for washing down the shed had been chlorinated that the trouble ceased.

2. A case of tainted milk attributed to the feeding of inferior hay was investigated. It appeared that the immediate cause of the trouble was the dust set up by the cows tossing the hay about in their endeavour to pick out the best bits, immediately before and during milking. When hay was withheld at this time the taint was no longer apparent.

3. In conjunction with Mr. Garner of the University Farm, a case of taint due to feeding of musty sugar-beet pulp was investigated. A series of samples of milk from two cows on identical rations, except for the substitution of fresh pulp in one ration for the musty pulp, were examined for taint. Microscopic examinations were made and various cultures prepared by inoculating sterile milk. Although in the majority of cases the milk from the cow receiving musty pulp was easily distinguishable because of its sweetish flavour, no significant differences in bacterial flora could be detected.

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98. MIDLAND AGRICULTURAL COLLEGE.

(*a*) *Farm water supplies.*—Investigations carried out at one farm have shown that the use of polluted farm water for washing cows' udders previous to milking can be responsible for gross contamination of the milk, where otherwise every possible care is taken. Of forty-eight farm water supplies examined during the year, thirty eight per cent. were found to be unfit for drinking or for dairy purposes.

(*b*) *Mastitis in Dairy Herds.*—The Advisory Bacteriologist for the Bristol area has pointed out that the presence of large numbers of chromogenic *staphylococci* on agar plates is an indication of some form of udder trouble in a herd. Attempts have been made to confirm this finding in several cases in this Province.

(*c*) *Discoloration of Leicester Cheese.*—Investigations have been commenced in collaboration with the Dairy Department on the

nature of the factors involved in the bleaching of the "annatto" colouring matter in Leicester cheese.

99. NEWCASTLE: ARMSTRONG COLLEGE.

Investigational work related to cases of abnormal milk and butter, sleepy cream, ropy milk, tallowy flavour in milk, cream defects, and mastitis.

Work is being carried out under a scheme for the eradication of bovine tuberculosis in the borough of Berwick-on-Tweed. In 1927–8 31·3 per cent. of the animals were reactors to the tuberculin test and of this number 3 per cent. were returned with positive mammary gland infection. In 1928–9 just over 20 per cent. of the animals gave positive reactions; of this number only 1½ per cent. showed positive mammary gland infection.

100. READING UNIVERSITY.

1. *The use of Andrade's Indicator in the presumptive B. coli test.*— Two hundred and forty-five comparative tests have been done using litmus and Andrade's solution. One hundred and forty-one showed the presence of acid and gas. In 98 cases (69.5 per cent.) both indicators were in total agreement. Further work is being done.

The following modification of the method of preparation of Andrade's Indicator has been carried out.

Dissolve 0.5 per cent. acid Fuchsin in distilled water.
Add N/1 NaOH till the red colour changes to a straw colour.
Remove 5 c.cs. from the bulk.
Titrate with N/10 NaOH until one drop of N/200 HCl will change the colour to pink.
Calculate the quantity of N/1 NaOH required to adjust the bulk to this reaction and add the necessary quantity to the bulk.
Allow to stand overnight; filter.

The indicator is added at the rate of 1 per cent. to the Bile Salt Peptone water.

2. *Dissolving Agar for use in the preparation of Nutrient Agar.*— Difficulty in effecting the solution of agar has been reported by Advisory Officers. Experiments to discover the cause have been made during which the difficulty was confirmed and the following procedure is suggested.

(1) *For one litre quantities*—
Dissolve by heating for 30 minutes at 100°C.

(2) *For three litre quantities*—
(*a*) Divide the bulk into three flasks of one litre each and heat for 30 minutes at 100°C.
(*b*) Dissolve by heating the bulk of 3 litres for 90 minutes at 100°C.

(*c*) Dissolve by heating the bulk of 3 litres in the autoclave at 120°C. (15 lb. pressure).

The autoclave is clamped and brought slowly up to a temperature of 120°C (15 lb. pressure), after which the pressure is slowly released.

Using method (*c*) subsequent filtering is much quicker and the final product is clearer. The product also pours better when plating.

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101. SEALE HAYNE AGRICULTURAL COLLEGE.

A certain amount of investigational work has been undertaken in connection with the various sources of infection of milk with spore-forming bacteria.

Certain types of these bacteria, when present, cause considerable trouble in the manufacture of scalded cream, and in consequence investigational work of this character is of great importance in Cornwall and Devonshire.

One of the commonest channels of infection seems to be the water supply, and several outbreaks have been traced to this source.

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102. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Abnormal Aroma in Milk.—A case of abnormal aroma was investigated and traced to the presence of a micrococcus. During the first twenty-four hours the milk developed an objectionable heavy odour, resembling that of amyl alcohol, and was rendered unfit for use. It was found that the growth of the causal organism could be controlled by thoroughly cooling the milk immediately after milking.

Cultivation of Lucerne.—Observations on a series of plots of six varieties indicated that Grimm's is the only frost-resistant variety of those tested. The severe frost of last winter almost completely destroyed five of the varieties while Grimm's was practically unaffected.

Life-Cycle of Bac. Amylobacter.—During the year practically all of the original observations made on the life-cycle of *Bac. amylobacter* have been confirmed. Stages have now been observed corresponding to the (1) large cell, (2) dwarfed growth, (3) fungoid, (4) coccoid, (5) short rod, and (6) large and (7) small sporing-rod stages of Löhnis and Smith. Cultures representing stages 4–7 have been stabilised and identified with previously described "species." A complete account of the investigation will be published.

Effect of Drying on the Microbiological Activities of Soil.—Mr. Khalil has now completed his work on this subject. His data indicate that the beneficial results from drying are not to be ascribed to the microbiological flora being rendered more active but rather to the organic matter being more easily decomposed.

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103. GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE.

A considerable number of feeding and other trials have been carried out, the two main subjects of study being the relative value of the succulent roughages and the position which certain concentrates can occupy in the dairy ration.

In addition the relation to production of such management problems as the influence of the age of the cow, the age of the heifer at the time of first calving and the lactation have also received attention.

Brief mention may be made of one or two results obtained which have not yet been published in detail. It has been found that roots, silage and dried beet pulp can all be used satisfactorily in the dairy ration. Palmnut meal can be used to replace bean meal in certain mixed rations. In the past there has been some difference of opinion as to whether corrections in variation of production brought about by the maturity of the cow should be made according to the age of the animal or according to the lactation. Work carried out during the past year shows that the two methods are equally satisfactory.

The following problems relating to cheesemaking and to the milk supply were studied in some detail during the past year :—

(*a*) The cause and origin of a serious flavour defect which appeared in mature Scots Cheddar and in Dunlop cheeses in the Season 1928.

(*b*) Colour defects in white and in coloured cheeses which have recently been reported in farm and factory cheese in this area, e.g., " staining," " black discoloration," " rusty spot." Work on bleaching of coloured Cheddar cheeses has been continued and amplified.

(*c*) The effect of pasteurising cheese milk to high temperatures by the " holding method " and the addition to the heat-treated milk of HCl.

(*d*) Weakness in coagulation, accompanied by a lack of body in the resultant cheese curd and the possibility of over coming this defect by the addition of certain salts.

(*e*) The relative merits of hand and of machine drawn milk for cheesemaking.

(*f*) The cause of slow-working cheese.

(*g*) The effect of including and excluding foremilk from the cheese vat.

(*h*) Burnt flavour in butter and cheese.

(*k*) Specific bacterial infections in market milk.

(*l*) Defects in flavour of milk not due to bacterial action or to metallic contamination from the utensils.

(*m*) Pin-point colonies of special origin apparent in plates made from raw and from pasteurised milk.

(*n*) Neglected factors in hygienic milk production.

Q.

ECONOMICS.

104. ABERYSTWYTH: UNIVERSITY COLLEGE OF WALES.

Survey records of milk costs are still being kept by a number of farmers. An economic survey of a parish in Carmarthenshire, including 80 dairy farms was made, and the results have been prepared for publication. The statistical analysis of records from a survey of Dairy Farming in North Wales has been completed. The investigation of labour requirements of crops and stock has been completed and a report prepared. Out of this investigation, and with the aid of other records, a "labour intensity index" for Wales has been prepared. A similar "labour intensity index" for England and Wales has been attempted. Attention has been given to some questions of population especially in relation to efficiency of labour and of farm organisation. On the marketing side, attention has been paid mainly to marketing of livestock in Wales. The analysis of finance and trading by co-operative (requisite) societies has been continued and developed. An investigation of the possibilities of growing and marketing potatoes in Pembrokeshire was conducted. Investigation of cyclical and other movements of prices of farm products has been particularly directed to prices and production of pigs.

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105. BRISTOL UNIVERSITY.

During the academic year 1928–9 the investigation into the costs of production on eleven farms was continued and the results were discussed with the farmers concerned. Where practicable the suggested changes in policy were put into operation and the effects are being watched by the advisory economist. Apart from these cost accounts, some farmers are using their own system of costing and request advice as to whether their methods are based upon correct principles.

The special investigation into the cost of growing sugar beet on forty farms in Herefordshire and Worcestershire was completed for the third year and a report forwarded to the Agricultural Economics Research Institute, Oxford, and to each of the farmers co-operating. This work has been continued for the fourth year, and there is considerable evidence that the growers are increasingly interested in the financial results.

The greater part of the research and investigational work at Bristol is concerned with problems of farm organisation and management arising from a study of financial accounts, of which 181 were analysed during the year under consideration. This work is steadily increasing, as requests are constantly being received from farmers who desire to be included in the scheme.

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106. CAMBRIDGE UNIVERSITY.

Three Reports, Nos. 11, 12 and 13, have been issued during the year. *Report No.* 11 concludes the series of economic and financial analyses covering cost accounting on certain farms for a period of four years, and refers to the financial year ending at Lady Day 1928. *Report No.* 12 summarises in 126 pages the results emerging from four years of economic investigation in the Province. Two methods of grouping the results are used, viz., (1) a size grouping, in which the economy of farms below 120 acres in size is compared with that of larger holdings, and (2) a soil grouping, in which the economy of those farms situated on the heavier types of soil is compared with that of farms situated on the lighter soil types. Complete cost data are given of fifteen different crops and five classes of livestock, while additional Tables give economic and statistical information on the distribution of cropping, distribution of capital, expenditures and receipts, employment statistics, output, private drawings, and profits and losses. Weighty evidence is adduced to show that farm losses in the Province during the years reviewed are attributable mainly to livestock enterprises. Such subsidiary information as the incidence of overhead charges, the cost of tractor work, the cost of farm yard manure, and the cost of bare fallows, receives considerable attention. *Report No.* 13, comprising 72 pages, details the results emerging from the second (1928) year's special investigation of the economics of sugar-beet growing. Like its predecessor (Report No. 9) the data refer to 100 farms and over 2,000 acres of sugar beet. The average net costs for the two seasons coincide closely, but the over-all cash profit, which in 1927 averaged 5s. 6d. per acre, was no less than 56s. 4d. in 1928. The sections dealing with the costs of and returns from the different manurial and cultural methods employed support strongly the conclusions arrived at in the 1927 Report. Fresh ground is broken in the Chapter dealing with the by-products of the crop, in which the disposal of tops and pulp is considered from the financial aspect.

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107. HARPER ADAMS AGRICULTURAL COLLEGE.

(*a*) *Costings*.—Seven farms were fully costed.

The costings were supervised on three further farms where the work of analysis was carried out throughout by the farmer.

(*b*) Two farms under the Nitram system of grassland management were completely costed.

(*c*) *Financial Accounts*.—Financial accounts have been collected and tabulated according to Weller's system on 47 farms.

(*d*) The survey of beet costs and returns was continued, the number of individual costs being increased to 100, covering an area of 1,076 acres. Close co-operation with the Advisory Chemist was maintained during the survey, and an attempt was made to correlate lime requirements with the cash returns from the crop.

The survey of general manuring was completed and a report circulated as is customary to participating farmers.

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108. LEEDS UNIVERSITY.

1. Two years' records of *Flax* growing in the Selby area are now available, and the economic value of the crop, particularly when grown from the new Pedigree seed, seems assured.

2. The special investigation with regard to *Potatoes* has been completed on the production side, and the results are now being worked up; it is hoped to continue the investigation into the marketing problems of the crop for at least another year.

3. *Marketing Problems*.—Realising the importance of marketing problems to the Agriculturist, attention is first being turned to those crops which are to a greater or less extent naturally protected by their "perishability" or their bulk; and it is hoped to complete marketing studies of *Peas Picked Green* this year and of *Potatoes* next year.

4. In mapping out an intensive study of the various systems of management of *Sheep* within the county, a commencement has been made with the hill flocks, which immediately brought up the problems of grazing of unenclosed moorlands, and of pastures held in common and grazed according to the varying customs of the manor in which they are situated.

5. *Historical work*.—Two areas, the Manors of Ingleton and Hooton Pagnell, are being selected for intensive study, the first in a typical sheep farming area, and the second in the industrial area of the West Riding. A good deal of interesting and useful information is coming to light, bearing upon the rights of common, the enclosure movement and the evolution of the modern farm from the open field system.

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109. MANCHESTER UNIVERSITY.

Investigation of the types of farm management found in Lancashire and Cheshire has been carried further, and progress has been made in the analysis of the qualities on which economic success is based. In connection with this research work, 427 farms and farmers have been visited during the past four years, some of them a great many times. To measure differences and changes in types

twelve grades are used, but a sufficient idea of the character of these may be given by the use of four classes. Of farms and farmers 13·6 per cent. are placed in the first class, 53·6 per cent. in the second class, 27·6 per cent. in the third class and 5·2 per cent. in the fourth class. Beyond those, 96 farms and farmers were visited in Cheshire for a different purpose. A less searching test was applied to their achievements, and 21·9 per cent. were placed in the first class, 65·6 per cent. in the second class and 12·5 per cent. in the third class. Of these 523 farmers, 34 have this year co-operated in modification of their management to see if by experiment they cannot increase their output and reduce their cost per unit at the same time. This co-operation has involved frequent visits and discussions with each farmer to give shape to the modified practice. Farmers do not lean too heavily on assistance, or act uncritically on advice. Records of experiments are kept, as well as of costs and yields wherever possible.

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110. MIDLAND AGRICULTURAL COLLEGE.

1. Farm management studies have been carried on by means of cost accounts, financial accounts and economic surveys. The number of cost accounts have, however, been reduced to five in order to introduce the survey method. The analysis of financial accounts submitted by a few farmers in Derbyshire was tried this year and proved fairly satisfactory. This work will be developed if the farmers are prepared to keep and submit their financial accounts to the department for analysis. A small number of sugar beet records are still being collected. A general economic survey was made of the Lincolnshire Wold area. Complete statistical information was obtained from seventy-eight farms for the financial year 1928/29, involving a total of approximately 40,000 acres.

2. A celery marketing and grading investigation was completed in the Isle of Axholme and the results of both this investigation and a previous survey are now being published. The results of the grading experiment particularly pointed to the need for the adoption of a system of grading by the growers. In addition to specific investigational work of the above nature, the advisory economist, as a member of the Marketing Committee of the Rutland and Stamford Farmers' Union, is jointly responsible for the marketing reports issued by that body.

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111. NEWCASTLE: ARMSTRONG COLLEGE.

1. *Farm Accountancy*.—The centre is responsible for the collection of economic data from representative farms in the Province and for the preparation of departmentalised accounts therefrom. During the year in question, six farms were co-operating in this line of work. These farms have just completed their third year under the scheme. The individual farmers have received annual reports based on the accounts prepared in the Department, but no attempt has been made as yet to generalise from the series.

2. *Other Investigations*. (i) *Black Currant Growing*.—Arising out of suggestions made by the Horticultural Advisers in the Province, an investigation into the economics of black currant growing as a possible "side line" to general farming was carried out. The material collected was not sufficiently conclusive to justify the issue of any general recommendations. On the critical factors of yield and price, the available data were drawn from favourable cases in which the crop was under relatively expert control and the variations in results, even with such control, were so wide that it was found impossible to present the subject in such a way that the general farmer, with no experience of bush culture, and with no supply of skilled labour available, might fairly appreciate the risks involved. Pending the accumulation of more adequate data, therefore, no report on the results of the investigation was issued.

(ii) *Prices of Fertilisers and Feeding Stuffs*.—With a view to ascertaining to what extent there existed differences in the prices paid by individual farmers for given fertilisers and feeding stuffs, an inquiry was instituted amongst some seven hundred and fifty farmers. The response was meagre and while the material collected suggested certain interesting lines for further investigation, the psychological effects of an inquiry which touched closely upon well-known confidential relationships between farmers and merchants were such that it was considered inadvisable to pursue the subject at the present stage.

(iii) *Sheep Farming in Northumberland*.—In connection with a survey of the trend in sheep farming in Northumberland made by the County Agricultural Organiser (Mr. W. S. Chalmers) an examination was made of the published livestock and crop statistics, and a further inquiry was made into the relation between mutton prices and carcase weights in the case of sheep killed locally for the London market.

The results were embodied in a paper given by Mr. Chalmers before the Agricultural Educational Association.

(iv) *Sugar Beet*.—During the winter 1928/29 the Branch carried out an investigation into the returns from sugar beet growing in the counties of Durham and Northumberland. This was a continuation of similar inquiries conducted in connection with the 1926 and 1927 crops. The results were published locally in bulletin

form under the title "Three Years of Sugar Beet Growing in Northumberland and Durham" and were also embodied in the national survey published by the Agricultural Economics Research Institute, Oxford.

In general, the investigation demonstrated the relatively poor results obtained in this part of the country, largely because of low tonnage yields, which offered no hope of economic returns. Unless the agricultural problems involved can be satisfactorily settled, the interest of northern growers may be expected to wane.

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112. OXFORD UNIVERSITY.

Farm Costing.—A full system of costing has been continued on 15 farms comprising 8,080 acres. Of these ten closed at Michaelmas, 1928, and five at Lady Day, 1929. The accounts have been completed and an analysis sent to each co-operating farmer.

Sugar Beet.—As part of the National Scheme of investigation which is being conducted by the Agricultural Economics Research Institute on the economics of sugar beet growing in England and Wales, costs of production and other relative information for the 1928 crops were secured from 27 growers in the province. Similar information is being collected in relation to the 1929 crop.

Grass Farming in the Welland Valley.—The field work commenced last year on the study of beef production in this district of Northamptonshire was completed during the year. A statement was prepared and circulated to each of the 87 farmers who co-operated. A full report is in course of preparation.

Poultry Keeping.—In connection with a Flock test scheme being conducted by the Oxfordshire County Council a system of accounts for the poultry enterprise was inaugurated, with the assistance of the County Poultry Instructors, on 16 farms in the County. The accounts closed on 31st October, 1929, and a report on the first year's working is to be prepared. It is hoped to extend this work in the following year.

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113. READING UNIVERSITY.

The cost accounting work of the Department, started in 1924, is being continued. During the year reports on the records of the earlier years have been published, one dealing with the economic and financial results on three arable-sheep farms, and the second with results on five dairy farms. At present eight farms, representative of various types of agriculture, are being costed by the Department, but no extension of this branch of the work is contemplated.

A farm survey of a dairying district in North-West Dorset is in progress. The object of this survey is the collection of data likely to throw light on the relative economic advantages of milk-selling and farm cheese-making as a means of disposing of the produce of the dairy herd.

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114. SEALE-HAYNE AGRICULTURAL COLLEGE.

1. *Financial Accounts*.—The 1927/28 accounts of 83 farms, covering 21,739 acres, were collected, analysed, and reported on during the year. Comparisons were made of the analysed results of each farm in 1927/28 with those of 1926/27 in each case where data were available. The farms were sorted into districts, and the different types of farming prevailing in each district were studied. Where grouping was based on the percentage receipts from the main branch of the farm, there was an indication that profits increased both as the percentage receipts from dairy products and poultry, and as the percentage receipts from crops, increased. They decreased as the percentage receipts from livestock became greater.

2. *Agricultural Survey*.—An agricultural survey was made in South Devon in the autumn of 1928, conjointly with Mr. J. R. Currie, of Dartington Hall, Totnes. At the invitation of Cornell University, the advisory economist accompanied Mr. Currie to the United States, where a joint report "An Agricultural Survey in South Devon" was written.

3. *Sugar Beet Costs*.—The economic aspect of the sugar beet crop in Devon and Cornwall in 1928 was investigated by Mr. Trevains. Costs and returns were obtained from 47 growers, covering 184 acres.

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115. WYE: SOUTH-EASTERN AGRICULTURAL COLLEGE.

At this centre the chief line of research work has been an investigation into farming costs of production and financial results on about 25 farms distributed throughout the Counties of Kent, Surrey, East Sussex and West Sussex. This investigation was commenced at Michaelmas, 1923, and a general report on the results for the six years to Michaelmas, 1929, is in course of preparation, in addition to further sectional reports on the lines of those already published.

A good deal of work has also been done in analysing the accounts of special cases, e.g., a specialised poultry farm, a Certified Milk farm, milk retailing farms, a large Romney Marsh sheep and cattle farm and so on. Although this kind of work does not so readily

lend itself to being written up in a formal report it is very highly appreciated by the farmers concerned and much more of it is waiting to be done.

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116. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Investigation of Farming Profitableness.—A considerable volume of work has arisen in connection with the collaboration of the College with the Department of Agriculture for Scotland in this investigation.

It is sought to secure financial accounts from an adequate sample of each type of farm, with a view to the publication of statistics regarding the economic position of Scottish agriculture. It is hoped, also, to provide co-operating farmers with figures comparing expenses and income on their own farms with group averages.

A considerable number of farms have been visited—co-operation being promised almost without exception. Good relations have been established with professional farm accountants.

Farmers having accounts readily give facilities for the incorporation of these into the College records, together with such further information as is required. The College is keeping accounts for a number of farmers who have hitherto been without them.

The data which can be secured seems to be limited only by the staff available.

III.

OTHER INVESTIGATIONS.

117. *SPARTINA TOWNSENDII* (RICE GRASS) IN ESSEX.

ESSEX COUNTY COUNCIL.

The main objects of the work in 1929 were:—

(*a*) the prevention of coast erosion.

(*b*) the provision of a supply of seed to meet overseas demand and

(*c*) the establishment of a crop which could be used as an emergency feed for stock and to provide material for examining other economic possibilities of the plant.

Two centres were laid down—one at Hadleigh in the Thames estuary and the other at Goldhanger on the Blackwater.

The main differences between the Hadleigh and Goldhanger sites are that at the latter the level is a few feet lower and the mud is much softer and is covered with a growth of Zostera grass. Further, at high water there is at Goldhanger a much wider expanse of water while tidal scour is probably less severe. At both centres the coast is protected by a sea-wall, outside of which are saltings and mud-flats of varying levels. The hinterland at Goldhanger is valuable fruit-growing land while that at Hadleigh is pasture.

The Rice Grass plants were set in regular rows roughly parallel to the wall beginning at its base and extending outwards about 50 yards.

At Hadleigh 8,000 plants were set at 2-yard intervals with a space of 4½ yards between the rows. The frontage covered is half a mile while the total area is about 14 acres. The depth of water at Spring tides varies from 4 feet at the ends of the plantation to about 6 feet at the centre. So far as depth of water is concerned, therefore, the situation is quite well suited to *Spartina*.

At Goldhanger 4,500 plants were set during June in one area approximately 100 yards long and varying from 30 to 50 yards in width. Because of the greater depth of water at Spring tides (7-8 feet) and the very soft nature of the mud a rather high mortality was anticipated. Accordingly the distances between the plants and between the rows was reduced to a few feet.

By August most of the plants at Hadleigh had become well established and some were showing signs of inflorescences. However, along one section of the front, extending for about 250 yards, the plants seemed to have completely failed. At present no reason can be assigned for this, but it is hoped that it will be possible in 1930 to make a critical investigation. This matter is regarded as important, as it appears from this experiment, and from others, that there is some factor or factors other than depth of water which limits the growth of *Spartina*.

At Goldhanger by the same date many of the plants in the outer rows had vanished, having probably been scoured out, others had failed to "take", but there remained, particularly in the inner

rows, a good percentage of survivors. These should make the nucleus of a strong plantation.

Overseas Transport of Plants and Seeds.—In response to numerous requests from the Dominions for seed, samples were sent to Australia, New Zealand, Tasmania, etc. Reports so far to hand show that only in one case was the seed viable on arrival. Concurrent tests were made at Chelmsford with the same stock of seed. 2,714 seeds were tested in various lots and the average germination was 53·7 per cent. There was, however, great variation. The highest rate was 97·7 per cent. and the lowest 7·4 per cent. The sample which travelled successfully overseas—to New Zealand—germinated at the rate of 23 per cent., so that it appears clear that there is considerable loss to be expected on such a long journey.

The period of vitality, according to our tests, was approximately 5 months.

Seed proving rather unsatisfactory for long journeys, the shipment of cuttings was tried. Two lots of about 100 cuttings each were specially packed by Messrs. Englemann of Saffron Walden and were shipped to Singapore and Hong Kong. They travelled in the vegetable room where the temperature is kept between 30° and 40°F. No report has yet come in from Hong Kong, but the Singapore correspondent replies that the plants arrived in first-rate condition. Tropical conditions, however, proved too much for them. Judging from this report it seems worth while considering this method of sending plants to those desirous of utilising *Spartina* in the Antipodes.

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118. TRIALS OF HARDY FRUITS FOR COMMERCIAL PURPOSES.

(Royal Horticultural Society and Ministry of Agriculture).

The hardy fruits under trial for commercial purposes now occupy nineteen acres at the Central Station at Wisley, and include ninety-five varieties of apple, nine pears, seventeen plums, eight cherries, three damsons, forty-four black currants, seventeen red and white currants, seventeen gooseberries, thirty-seven raspberries, twenty strawberries, seven other berries, and one nut. Eleven varieties of various kinds have been withdrawn from the trials as unlikely to prove of commercial value.

Of the varieties under trial seventeen varieties of black currants, five red currants, five gooseberries, thirteen raspberries, and three apples have been or are about to be distributed to the ten substations in addition to twenty varieties of Canadian apples in small numbers.

The substations are situated at East Malling, Merton, Long Ashton, Elbridge (Cornwall), Perdiswell (Worcester), Cambridge, Emneth (Norfolk), Wisbech, Osgodby (Yorks), Houghall (Durham),

In all of these the trials are making good progress.

Varieties of raspberry are being tested for their value for canning, and a considerable area is devoted to an experiment designed to ascertain the number of bushes needed to give a close approximation of the yield of a given variety of black currant.

A very large collection of various kinds of hardy fruits is maintained at Wisley for comparison with the varieties in the trials and for determination of synonymy.

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119. KEMP IN THE FLEECE OF WELSH MOUNTAIN SHEEP.

(Bangor: University College of North Wales).

One of the most important considerations in connection with the occurrence and significance of kemp is its relation to the birth-coat of the lamb. Breeding experiments have shown that the type of birth-coat is inherited. There is strong indication of multiple factor inheritance, probably not very many main factors being involved. The efficiency of selection in producing the required type of birth-coat has been demonstrated.

Concurrently, observations have been made on the proportion of kemp in the fleeces of the experimental sheep and it will be possible to add these results to those of the *ad hoc* breeding experiment now in progress.

All the sheep have been carefully graded both from the breeder's point of view and by a practical wool expert.

A number of lambs were ear-marked at birth and observations have been made on their coats at frequent intervals. The change from birth-coat to adult coat has been studied. Numerous conclusions have emerged: for example, information as to the earliest time in the life of the lamb at which it is possible to form a judgment on the subsequent nature of the adult fleece; the relation between kemp and coarse hair, etc.

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120. FLUCTUATIONS IN THE NUMBERS OF WILD RODENTS.

(Department of Zoology and Comparative Anatomy, University Museum, Oxford)

The research can be divided conveniently into two parts:—

(1) Fluctuations in numbers of British rodents.
(2) Fluctuations in numbers of rodents in other parts of the world.

1. Mr. A. D. Middleton has organized a large team of observers (about 800) in the British Isles, to supply data about cycles in numbers of field-mice (voles) and squirrels, together with other

species of animals. The results so far obtained prove that British mice undergo rather regular short-period cycles in numbers, similar to those in other parts of the world, and that the phenomenon can therefore be studied conveniently in the British Isles, where there are facilities for research. Special attention has been paid to the causes of the cycles, and to the damage caused by voles to forest tree seedlings.

Squirrels have been found to have a cyclical variation in numbers, in which a disease of unknown origin and cause plays an important part. This has an important bearing upon destruction of forest trees by the red squirrel.

Various experiments have been initiated, to test the factors at work in these cycles.

2. The Norwegian lemmings and mice undergo cycles in numbers which have been studied by Mr. Elton, and these cycles run parallel in Britain and Norway, indicating some climatic factor controlling both, a factor at present not properly understood; the elucidation of this climatic influence will clear up one of the most important problems connected with mouse cycles.

A study of fluctuations in Canadian animals has been carried out with the co-operation of the Hudson's Bay Company.

Mr. Elton is also carrying out similar studies upon the rodent cycles occurring in other parts of the Empire and in foreign countries, in order to attempt a co-ordination of the whole field of research.

Experimental work is being carried out upon the migratory behaviour of field-mice under different conditions. Migration has been found to play an important part in the lives of these rodents, and therefore in the economic effects which they have upon agriculture and forestry.

APPENDIX.

LIST OF DIRECTORS OF RESEARCH INSTITUTES AND HEADS OF ADVISORY CENTRES.

I. RESEARCH INSTITUTES.

A. Soils, Plant Nutrition and Plant Physiology.

(1) Sir E. J. Russell, D.Sc., F.R.S.
Rothamsted Experimental Station, Harpenden, Herts.

(2) Prof. J. Hendrick, B.Sc.
Agricultural Dept., Marischal College, Aberdeen.

(3) R. G. Baskett, Esq., B.Sc.
Chemical and Animal Nutrition Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

(4) Prof. V. H. Blackman, Sc.D., F.R.S.
Research Institute of Plant Physiology, Imperial College of Science and Technology, South Kensington, S.W.7.

B. Plant Breeding, Crop Varieties and Seeds.

(5) Sir R. H. Biffen, M.A., F.R.S.
Plant Breeding Institute, School of Agriculture, Cambridge.

(6) Prof. R. G. Stapledon, M.A.
Welsh Plant Breeding Station, Agricultural Buildings, Alexandra Road, Aberystwyth.

(7) W. Robb, Esq., N.D.A.
Scottish Society for Research in Plant Breeding, Craigs House, Corstorphine, Midlothian.

(8) Ian W. Seaton, Esq., B.Sc.
Plant Breeding Division, Ministry of Agriculture for Northern Ireland, Stormont, Strandtown, Belfast.

(9) W. H. Parker, Esq., M.A.
National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

(10) T. Anderson, Esq., M.A., B.Sc.
Seed Testing and Plant Registration Station, Department of Agriculture for Scotland, East Craigs, Craigs Road, Corstorphine, Midlothian.

(11) R. Rae, Esq., B.Agr.
Crop and Animal Husbandry Division, Ministry of Agriculture for Northern Ireland, Agricultural Research Institute, Hillsborough, Co. Down.

C. Horticulture and Glasshouse Crops.

(12) Prof. B. T. P. Barker, M.A.
Agricultural and Horticultural Research Station, Long Ashton, Bristol.

(13) R. G. Hatton, Esq., M.A.
East Malling Research Station, East Malling, Kent.

(14) Sir R. H. Biffen, M.A., F.R.S.
Horticultural Research Station, School of Agriculture, Cambridge.

(15) W. F. Bewley, Esq., D.Sc.
Experimental and Research Station, Cheshunt, Herts.

D. Entomology and Plant Pathology.

(16) J. C. F. Fryer, Esq., O.B.E., M.A.
Plant Pathological Laboratory, Milton Road, Harpenden, Herts.

(17) R. N. Salaman, Esq., M.D.
Potato Virus Research Station, School of Agriculture, Cambridge.

(18) F. T. Brooks, Esq., M.A.
Botany School, Cambridge.

(19) J. W. Munro, Esq., M.A., D.Sc.
Biological Field Station, Slough, Bucks.

(20) Mrs. N. L. L. Alcock.
Plant Pathological Laboratory, Department of Agriculture for Scotland.

(21) S. P. Mercer, Esq., B.Sc.
Seed Testing and Plant Diseases Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

E. Agricultural Parasitology.

(22) Prof. R. T. Leiper, M.D., D.Sc., F.R.S.
Institute of Agricultural Parasitology, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.

F. Animal Pathology.

(23) F. C. Minett, Esq., D.Sc., M.R.C.V.S.
Research Institute in Animal Pathology, Royal Veterinary College, Camden Town, N.W.1.

(24) Prof. J. B. Buxton, M.A., F.R.C.V.S.
Department of Animal Pathology, Cambridge University.

(25) W. H. Andrews, Esq., D.Sc., M.R.C.V.S.
Veterinary Laboratory, Ministry of Agriculture and Fisheries, New Haw, Weybridge, Surrey.

(26) J. Russell Greig, Esq., M.R.C.V.S.
Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh.

(27) (*a*) Prof. E. P. Cathcart, C.B.E., M.D., F.R.S.
Hannah Dairy Research Institute, Auchincruive, Ayr.
(*b*) O. C. Bradley, Esq., M.D., D.Sc.
Royal (Dick) Veterinary College, Edinburgh.

(28) J. P. Rice, Esq., B.Sc., M.R.C.V.S.
Animal Diseases Division, Ministry of Agriculture for Northern Ireland, Stormont, Strandtown, Belfast.

G. Animal Nutrition and Breeding.

(29) F. H. A. Marshall, Sc.D., F.R.S.
Animal Nutrition Institute, School of Agriculture, Cambridge.

(30) J. B. Orr, Esq., D.S.O., M.C., M.A., M.D., D.Sc.
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(31) R. G. Baskett, Esq., B.Sc.
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(32) (*a*) C. Crowther, Esq., M.A., Ph.D.
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(*b*) R. M. Wilson, Esq., B.Sc.
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(33) R. T. Parkhurst, Esq., M.Sc.
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(34) Prof. R. C. Punnett, M.A., F.R.S.
Small Animal Breeding Research Institute, Whittingehame Lodge, Cambridge.

(35) Prof. F.A. E. Crew, M.D., D.Sc., Ph.D.
Animal Breeding Research Department, King's Buildings, West Mains Road, Edinburgh.

H. Dairying.

(36) R. Stenhouse Williams, Esq., M.B., D.Sc.
National Institute for Research in Dairying, Shinfield, nr. Reading.

(37) Prof. E. P. Cathcart, C.B.E., M.D., F.R.S.
Hannah Dairy Research Institute, Auchincruive, Ayr.

(38) G. Wilson, Esq., M.R.C.V.S., D.V.S.M.
Dairy Bacteriology Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

I. Agricultural Economics.

(39) C. S. Orwin, Esq., M.A.
Agricultural Economics Research Institute, Parks Road, Oxford.

(40) J. S. King, Esq., Ph.D.
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J. Preservation and Transport.

(41) Sir W. B. Hardy, M.A., LL.D., F.R.S.
Low Temperature Research Station, Cambridge.

(42) F. Hirst, Esq., M.Sc. (Acting Resident Director).
Fruit and Vegetable Preservation Research Station, Chipping Campden, Glos.

K. Agricultural Engineering.

(43) B. J. Owen, Esq., M.A., M.Eng., D.Sc.
Institute of Agricultural Engineering, 37a, St. Giles, Oxford.

II. ADVISORY CENTRES.

(52, 69, 82, 92, 99, 111) Prof. J. A. Hanley, Ph.D.
Armstrong College, Newcastle-on-Tyne.

(46, 62, 75, 96, 105) Prof. B. T. P. Barker, M.A.
Agricultural and Horticultural Research Station, Long Ashton, Bristol.

(47, 63, 76, 97, 106) Prof. F. L. Engledow, M.A.
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(48, 65, 78, 107) C. Crowther, Esq., M.A., Ph.D.
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(49, 66, 79, 108) Prof. R. S. Seton, B.Sc.
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(50, 67, 80, 109) J. Orr, Esq., M.A.
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(91) Prof. S. H. Gaiger, F.R.C.V.S.
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(51, 68, 81, 98, 110) T. Milburn, Esq.
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(53, 70, 83, 112) Prof. J. A. S. Watson, M.A.
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(54, 84, 100, 112) Prof. H. A. D. Neville, M.A., B.Sc.
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(55, 71, 85, 101, 114) D.R. Edwardes-Ker, Esq., O.B.E., M.A.
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(56, 72, 86, 93, 115) R.M. Wilson, Esq., B.Sc.
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(44, 60, 73, 94, 104) Prof. J. J. Griffith, B.Sc.
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(45, 61, 74, 89, 95) Prof. R. G. White, M.Sc.
Department of Agriculture, University College of North Wales, Memorial Buildings, Bangor.

(64, 77, 90) Principal, A. H. Trow.
University College of South Wales and Monmouthshire, Cathays Park, Cardiff.

(57, 58, 87, 102, 116) Prof. E. Shearer, M.A., B.Sc.
Edinburgh and East of Scotland College of Agriculture, 13, George Square, Edinburgh.

(59, 88, 103) Prof. W. G. R. Paterson, B.Sc., N.D.A.
West of Scotland Agricultural College, 6, Blythswood Square, Glasgow.

III. OTHER CENTRES OF INVESTIGATION.

(117) The Principal.
East Anglian Institute of Agriculture, Chelmsford.

(118) F. J. Chittenden, Esq.
Royal Horticultural Society's Gardens, Wisley, Surrey.

(119) Prof. R. G. White, M.Sc.
Department of Agriculture, University College of North Wales, Memorial Buildings, Bangor.

(120) Prof. E. S. Goodrich, M.A., D.Sc.
Department of Zoology and Comparative Anatomy, University Museum, Oxford.

SUBJECT INDEX.